MONETARY MEASUREMENT OF ENVIRONMENTAL GOODS AND SERVICES: FRAMEWORK AND SUMMARY OF TECHNIQUES FOR CORPS PLANNERS

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PREFACE

This study was conducted as part of the *Evaluation of Environmental Investments Research Program* (EEIRP). The EEIRP is sponsored by Headquarters, U.S. Army Corps of Engineers (HQUSACE). It is jointly assigned to the U.S. Army Engineer Water Resources Support Center (WRSC), Institute for Water Resources (IWR), and the U.S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL). Mr. William J. Hansen of IWR is the Program Manager and Mr. H. Roger Hamilton is the WES Manager. Program Monitors during this study were Mr. John W. Bellinger and Mr. K. Brad Fowler, HQUSACE. The Field Review Group members that provided overall Program direction and their District or Division affiliations were: Mr. David Carney, New Orleans; Mr. Larry M. Kilgo, Lower Mississippi Valley; Mr. Richard Gorton, Omaha; Mr. Bruce D. Carlson, St. Paul; Mr. Glendon L. Coffee, Mobile; Ms. Susan E. Durden, Savannah; Mr. Scott Miner, San Francisco; Mr. Robert F. Scott, Fort Worth; Mr. Clifford J. Kidd, Baltimore; Mr. Edwin J. Woodruff, North Pacific; and Dr. Michael Passmore, WES (formerly with Walla Walla District).

The work was conducted under the Monetary and Other Valuation Techniques work unit of EEIRP. During various periods, Dr. Gerald D. Stedge and Mr. William Hansen of IWR have served as the Principal Investigator. Mr. John Titre is the co-Principal Investigator at WES. This report is one of a series of Technical Reports produced as part of this work unit, each of which will support the development of an Environmental Valuation Procedures Manual.

The work was performed by Apogee Research, Inc., under Task Order 0011, Contract No. DACW72-95-D-0001. Mr. Paul F. Scodari was the principal investigator, under the general supervision of Ms. Amy Doll and Dr. Kenneth I. Rubin. Dr. Walter Milon, Department of Food and Resource Economics, University of Florida, and Dr. Alan Randall, Department of Agricultural Economics, The Ohio State University, served as expert reviewers of the report. Mr. Kevin Needham and Mr. David Novak contributed to the research and analysis for this report.

The report was prepared under the general supervision at IWR of Mr. Michael R. Krouse, Chief, Technical Analysis and Research Division; and Mr. Kyle E. Schilling, Director, IWR; and at EL of Mr. H. Roger Hamilton, Chief, RAB; Dr. Robert M. Engler, Chief, NRD; and Dr. John W. Keeley, Director, EL.

At the time of publication if this report, Mr. Kyle E. Schilling was Acting Director of WRSC and Dr. Robert W. Whalin was Director of WES. The Commander of WES was COL Bruce K. Howard, EN.

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1. INTRODUCTION

1.1 Purpose

This report provides information on the potential applicability and use of monetary measurement techniques (also referred to herein as economic benefits estimation or valuation techniques) for environmental project planning studies within the Corps of Engineers' Civil Works Program. As will be discussed further below, in some cases it may be possible and desirable to estimate the monetary benefits associated with certain environmental outputs provided by ecosystem restoration projects. The purpose of this report is to help project planners better understand what tools are available for estimating the monetary benefits of environmental outputs, when they may be technically appropriate to use, and their potential resource requirements in the ecosystem restoration context.

A variety of economic techniques are available for estimating the monetary benefits provided by nonmarketed, environmental goods and services. Most of these tools are described in very broad terms in economic textbooks and in very technical terms in economic journals, leaving an information gap which often makes it difficult for potential practitioners to evaluate their potential applicability and use in different contexts. Additionally, very little summary information has been compiled concerning the data requirements of these techniques, the time it takes to perform such analyses, and the technical expertise required to use the techniques effectively.

This report attempts to address these information gaps by providing Corps planners with a summary of selected economic valuation techniques and their resource requirements, and a framework for evaluating their potential applicability and use for ecosystem restoration project planning. A forthcoming “Procedures Manual” will provide more detailed information on the evaluation and potential use of these tools for planning purposes. That manual will link the information contained in this report with information from other reports prepared as part of the EEIRP Monetary and Other Valuation Techniques Work Unit, as well as the Corps’ National Economic Development Procedures Manual Series.

1.2 Applicability and Intended Audience

This report was developed primarily for use by Corps field planners at district offices involved with planning and evaluating environmental restoration projects. In an effort to make the report accessible to this target audience, the use of technical terms and mathematics has been avoided wherever possible. Still, some of the material presented, particularly that which relates to the theoretical bases for the valuation techniques, may require an existing understanding of fundamental economic concepts and principles. For those readers who find this material difficult, these sections can be skipped over; other parts of the text should be sufficient to provide a sound conceptual understanding of the techniques presented and their applicability and potential use in the ecosystem restoration context.

1.3 Monetary Measurement in the Environmental Project Planning Process

Economic benefits analysis is an integral component of the Corps planning process for traditional projects (e.g., navigation and flood damage reduction). For traditional water resource development planning, the Corps has long been required to estimate the economic benefits of project outputs in monetary terms to facilitate the evaluation of alternative plans in cost-benefit analyses.

Unlike the traditional project context, the Corps is not required to estimate the monetary benefits associated with ecosystem restoration projects for restoration planning. Indeed, the economic framework--which focuses on the welfare of humans--is inadequate to the task of valuing such things as the protection and improvement of biodiversity and basic ecological functions and processes which are central objectives of the Corps' restoration program. Nevertheless, in some cases it may be possible and desirable to estimate the monetary benefits of some subset of the environmental outputs provided by an ecosystem restoration project. For example, economic valuation tools may be applicable and useful in the case of large-scale and complex restoration projects involving multiple and otherwise non-commensurable environmental outputs, or particular outputs associated with large and estimable monetary benefits. In such cases the use of economic valuation tools could help to reduce the number of non-commensurable trade-offs needed for project evaluation by expressing one or more restoration outputs in economic terms commensurable with estimated project costs. Of course, a variety of policy and practical constraints on Corps planners may make the use of these techniques inappropriate for many environmental project planning scenarios.

Integration of economic valuation techniques into the Corps environmental planning process is relatively new. The reader may want to refer to EC 1105-2-210, *Ecosystem Restoration in the Civil Works Program*, (1 June 1995) for guidance on restoration planning in the Corps Civil Works Program. It presents Corps guidance on measuring restoration project outputs in monetary and non-monetary terms.

1.4 Organization of Report

Chapter 2 provides an overview of the selected valuation tools and presents summary tables to help planners evaluate which techniques, if any, may be appropriate for a particular planning study. The remaining chapters present a summary of four selected economic techniques, and one procedure for transferring valuation results estimated in previous studies using these techniques. The valuation techniques selected for this report, and the chapter for each technique, are listed below:

- Factor Income/Productivity Method (Chapter 3),
- Travel Cost Models (Chapter 4),
- Hedonic Property Value Method (Chapter 5), and
- Contingent Valuation Method (Chapter 6).

Chapter 7 presents the "benefits transfer" procedure mentioned above. Chapter 8 presents a list of references compiled from the previous chapters and additional key references that may be useful to Corps planners as sources of more detailed information for the valuation techniques.

2. OVERVIEW OF TECHNIQUES FOR ESTIMATING THE ECONOMIC BENEFITS OF ECOSYSTEM RESTORATION

2.1 Introduction

To provide context for the discussion of economic benefits assessment techniques presented in this report, this section provides a brief summary of the Corps' involvement in ecosystem restoration, the various ways in which ecosystems can contribute to social welfare, and the conceptual basis for estimating the monetary benefits provided by ecosystem restoration projects. It then provides an overview of the valuation techniques considered in this report and a summary of the resources required for their application in the ecosystem restoration planning context.[1]

2.2 Ecosystem Restoration and the Corps

Ecosystem restoration is the process of rehabilitating and repairing degraded ecosystems. USACE restoration activities concentrate on ecological resources and processes that are directly or indirectly associated with or dependent upon the hydrologic regime of the ecosystem and watershed. The Corps' participation in restoration projects to date typically has involved modifying or changing the operating features of existing Corps structures so that certain natural ecosystem elements are returned to some earlier condition. These activities focus primarily on engineering solutions to resource problems, including excavation and the construction or placement of structures to contain, redirect, or exclude water flow and sediment transport. Corps projects may be relatively small-scale and straightforward, such as removing small flood control dikes or making minor changes to road culverts in order to improve water flow regime to a wetland system. Corps projects can also be very large or complicated, such as projects to alter or remove dams or systems of levees, or to make changes in reservoir operating rules in order to restore pre-dam flow patterns. The ongoing effort to restore the pre-channelization sinuosity of the Kissimmee River in Florida is an example of a large-scale restoration project which involves many complicated features.

The primary direct intent of Corps restoration activities is to change the topographical and hydrological features and morphologic processes of watersheds and parts thereof, including tidal and non-tidal wetlands; rivers, streams, and associated riparian habitat; and lakes and estuaries. These ecosystems often provide bundles of environmental services, the supply or quality of which can often be increased through restoration efforts. The economic assessment of ecosystem improvements resulting from Corps restoration projects refers to the process of estimating, in dollar terms, the net increase in social welfare associated with changes in the quantity or quality of the ecosystem services affected by restoration. Even though the Corps is not required to evaluate the monetary benefits of restoration projects under consideration, the ability to measure in dollar terms the benefits associated with the expected change in one or more ecosystem services could provide the Corps with an improved basis for decision making regarding project options for some site (the site question), as well as for ranking projects being considered for different restoration sites (the portfolio question). For

[1] The intent of this section is to provide an overview of the concepts and techniques for estimating ecosystem restoration benefits. For a thorough treatment of the theory and practice of measuring environmental and natural resource values, see: Braden and Kolstad (1991) and Freeman (1993).

example, restoration project options under consideration involving a particular riverine system might be expected to improve the quality of the recreational opportunities it provides. If the additional recreational benefits provided by the various project options could be quantified and measured monetarily, they then could be netted from the estimated project costs to provide net cost estimates for the project options. These estimates of net costs could then serve as the basis for cost-effectiveness analysis using, as the measure of expected benefits, some quantified physical measure of the expected improvement in the ecosystem.[2]

2.3 Economic Value of Ecosystem Services[3]

Aquatic ecosystems are associated with a variety of ecological outputs (structural characteristics and functional processes) which generate useful services to humans. These services result in various types of social benefits, including: (1) direct use values, (2) indirect use values, and (3) nonuse (existence) values. Restoration of ecosystems can affect ecological outputs in a manner that will often increase the supply or quality of human services and their associated social values. The major types of human services that can be augmented through restoration efforts and the types of benefits they provide are summarized in Table 2.1 and outlined below.

First, ecosystem restoration efforts can affect various human services that generate *direct use values* in production or consumption. Ecosystem restoration can generate direct use values by, for example:

1) Increasing the quantity of commercially valuable organisms and natural products (e.g. finfish, shellfish, fur-bearing animals, hay);

2) Increasing the productivity of the land/water resource base used as inputs for agricultural and industrial production;

3) Increasing the supply or quality of water for municipal and residential uses;

4) Increasing the supply or quality of recreation opportunities (e.g. swimming, boating, recreational fishing, hunting, nature study), and;

5) Increasing the beauty of natural surroundings for nearby residential communities.

Second, ecosystem restoration can generate *indirect use values* by augmenting ecological outputs that indirectly contribute to consumer utility by supporting and preventing damage to a wide

[2] This technical example of the use of benefit and cost estimates for project evaluation ignores relevant policy issues, such as separable project costs and cost sharing factors, that would need to be considered by project planners (see: Robinson, et al., 1995).

[3] Parts of this subsection were taken directly from (with minor modification) Cole, et al. (1996).

Table 2.1 Economic Value and Ecosystem Services

Type of Value	Ecosystem Service
Direct Use Values in Production	Market and nonmarket services that are used as productive inputs for market-valued goods and services • Resource (e.g. channel, basin) input in navigation and hydropower production • Land productivity for food and fiber production, commercial and industrial production • Water input for industrial processes and municipal/residential water supply • Commercially harvested fish, wildlife, and natural products
Direct Consumptive and Non-consumptive Use Values	Nonmarket services that contribute to consumer utility through direct use • Aquatic habitat-based consumptive recreation (e.g., fishing, swimming, boating, waterfowl hunting) • Amenities/aesthetics (e.g. visual and cultural benefits) • Water-enhanced, non-consumptive recreation (e.g., picnicking, bird viewing, camping)
Indirect Use Values	Nonmarket ecological services that indirectly contribute to consumer utility by supporting and preventing damage to a wide range of market and nonmarket activities • Flood storage and conveyance • Sediment retention • Wind and wave buffer • Pollution uptake and detoxification
Nonuse Value	Existence value associated with the knowledge that an ecosystem and its ecological outputs (e.g. biodiversity) and human services are intact, independent of any actual or anticipated use

range of market and nonmarket activities. Wetlands, for example, provide natural filtering, nutrient uptake, and detoxification of pollutants that would otherwise flow into watercourses. Restoration of wetlands can also augment ecological outputs involving the regulation and attenuation of flood waters and the trapping of eroded sediments. These services may reduce costly damages that otherwise might arise to commercial and residential property and infrastructure.

Third, ecosystem restoration can sometimes generate significant *nonuse or existence values* to many members of the public associated with simply knowing that a particular ecosystem and its service flows exists and will be available for future generations to enjoy. Unlike direct and indirect use values, existence values are independent of peoples' actual or planned use of ecosystems and their services. Existence values are most likely to be associated with ecosystem characteristics and services that are scarce at the margin and have few substitutes. Thus, unique ecosystems may be associated with existence values relating to one or more of their structural characteristics or service flows. For example, a wetland system that provides the last remaining habitat for several species of endangered birds may generate existence values associated with this wildlife diversity. But even ecosystem types and services that are relatively abundant nationally may still provide important local or regional existence values.

Environmental restoration projects can potentially increase the quantity (amount, duration, areal extent) and quality (improve the timing, rate, or reduce variability) of the ecosystem services described above. As will be explained below, the value of increases in the supply or quality of ecosystem services is reflected by any resulting increase in the public's net willingness to pay (demand) for these services. That is, in order for increases in the supply or quality of ecosystem services to generate additional economic value, it must be possible to connect a human demand to the ecological effect (e.g. a human demand to hunt the additional waterfowl, to view the additional birds, to swim in water of improved quality) The linkage can be indirect as well as direct. For example, humans may not care if the soil toxicity in an ecosystem is reduced as a result of restoration, thus providing suitable habitat for pocket gophers. But since pocket gophers are a major part of the red-tailed hawk's diet, and people enjoy viewing the hawks, there is a human demand for clean soil and pocket gophers, indirectly through the food chain. In some cases, there is a human demand to know that the natural functions have been restored to an area such that it will now support native plants, fish, and wildlife, independent of any actual or planned use of the area. That is, there may be an existence demand associated with the knowledge that the restored area exists as habitat or performs ecological functions.

When investigating which of the possibly several human services affected by a proposed restoration project are candidates for monetary measurement, it is important for the analyst to look at the anticipated demand for the new services relative to the existing supply of those services. Restoration of additional habitat may at some point saturate the "market" for the associated human services, and each new project simply redistributes the same fixed amount of use. The Corps has seen this phenomenon with regard to recreation projects in certain reservoir-rich regions of the U.S.

The importance of there being a demand for the additional supply of ecological services created by the restoration project can be illustrated with a few examples. First, consider the case where there is a demand for both the current supply and the augmented supply of a recreational service such as waterfowl hunting and viewing in a particular wetland area. A restoration project that increases the quantity of the wetlands is translated into an increase in the supply of hunting and viewing days, which in turn allows for the issuance of more waterfowl hunting permits or allows for more viewing blinds to be constructed to accommodate more bird watchers. The benefits of these added recreational trips or visitors is reflected by the public's additional willingness to pay for these expanded recreational opportunities (net of the additional travel costs and management costs of accommodating the additional visitors).

Now consider the case where the restoration of the wetland will augment its ability to increase the supply of locally available groundwater. If there already is an abundance of high-quality groundwater supply to meet all economic demands in the area, and the additional water resulting from restoration does not reduce the cost of meeting existing water demand, then there is no current demand for increased groundwater recharge resulting from the restoration project. That is, while wetland restoration provides additional bird hunting and viewing benefits, the additional groundwater recharge service has no current economic value today. Benefits with and without the increase in the supply of groundwater are the same.

Tracing the ecological effects of restoration efforts to how they affect human behavior is central to the economic estimation of restoration benefits. A recent IWR report prepared as part of the EEIRP (Cole, et al., 1996) provides guidance for tracing the effect of Corps management approaches on the physical changes in ecosystems, their potential ecological effects, and the types of human services that might be affected. That report also provides screening factors that can help Corps restoration planners to determine if there may be a human demand for increases in the supply or quality of ecosystem services resulting from ecosystem restoration.

2.4 Conceptual Basis for Estimating Ecosystem Restoration Benefits

For the evaluation of proposed civil works projects relating to navigation, flood control, and other traditional Corps missions, the agency has long been required to estimate the "National Economic Development" (NED) benefits associated with the additional goods and services generated by the project. The *Principles and Guidelines* (Water Resources Council, 1983), which establishes the appropriate concepts, procedures and techniques for analytical studies used to evaluate the NED effects of civil works plans, requires that NED benefits be measured in terms of the public's net willingness to pay (WTP) for the additional goods and services expected from plan implementation. Net WTP is the amount that the users of the additional goods and services would pay, over and above their own costs, to obtain the project outputs.

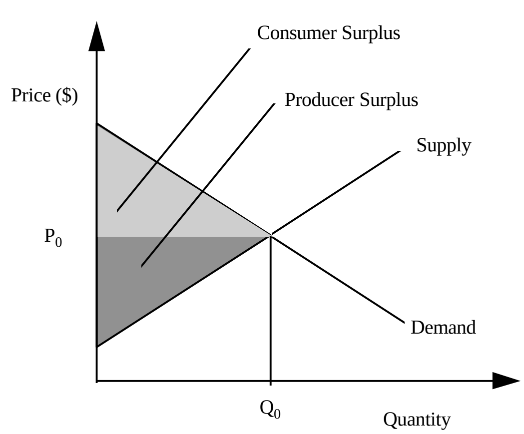
Estimation of one or more categories of NED effects associated with ecosystem restoration projects is conceptually the same as that for traditional civil works plans: the NED effects from increases in the supply or quality of ecosystem services are appropriately measured as the net amount that the users (e.g., visitors, homeowners) would pay, over and above their own costs, to obtain the improvement. The improvement might be cleaner water, greater diversity of birds, less odor, or greater in-stream flow. And WTP for augmented ecosystem services can also reflect a cost savings to society. For example, the cost savings to a reservoir owner from less sediment in the water can be measured by the reduced cost from less frequent dredging. Flood damage costs avoided by homeowners is another type of possible NED benefit associated with augmented ecosystem services that can be used to proxy landowner's WTP to avoid property losses.

Economic Surplus Measures of Net WTP

Below, the case of a marketed good is used to illustrate the concept and measurement of economic welfare. When a good is traded in competitive markets, defined by the presence of many buyers and sellers, its market price--which equates demand for the good with the supply of the good--measures consumers' WTP for the last unit of the good purchased. For all other units of the good purchased, however, consumer's marginal WTP for each unit exceeds the good's market price. The excess of what consumers are willing to pay over what they do pay for the total quantity of a good purchased is called consumer surplus. This consumer surplus approximates the value of the good to consumers in terms of net WTP, and is represented by the area under the market demand curve for the good, bounded by market price (see Figure 2.1).

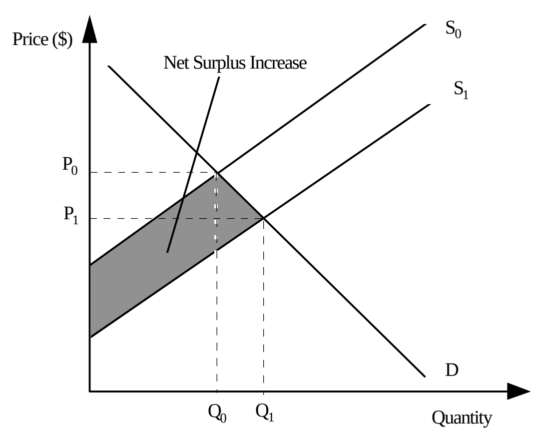
A good's market-clearing price also corresponds to the marginal cost of producing the last unit of the good sold. For all other units produced and sold, however, producers' marginal production costs for each unit is less than the market price received. The excess of what producers earn over their production costs is called producer surplus. Producer surplus reflects the net value of the good to producers in terms of profit, and is represented by the area above the good's market supply curve bounded by market price (see Figure 2.1).

Figure 2.1 Consumer and Producer Surplus for a Marketed Good



Because the surplus measures discussed above reflect the net WTP of consumers to consume and producers to produce a marketed good, they are often used to estimate the change in benefits associated with a structural change in either demand or supply. For example, consider the case in which there is a drop in the price of a key factor input used in the production of a marketed good (see Figure 2.2). This would shift outward the market supply curve for the good, reflecting the lower cost of producing it at any given level of quantity supplied. This would result in a fall in the good's market price (from P_0 to P_1) and an increase in the quantity of the good produced and consumed (from Q_0 to Q_1) , which in turn would change consumer and producer surpluses. If the relevant demand (marginal value) and supply (marginal cost) functions could be empirically estimated, the net surplus change could be calculated to approximate the net benefits associated with the price and quantity change.

Figure 2.2 Welfare Effects of an Increase in the Supply of a Marketed Good



For a variety of reasons, most of the ecosystem services that might be augmented through restoration efforts are not traded in organized markets. For example, ecosystem services such as recreation and flood control represent public (collective) or quasi-public goods for which potential consumers are generally difficult to exclude. This characteristic of ecosystem services generally precludes landowners from charging fees for the benefits that aquatic ecosystems provide to the public. When ownership of an asset is not a requirement for consuming the services it provides, then its market price will not reflect the benefits provided by its services. Moreover, since one person's consumption of a collective ecosystem service does not preclude or reduce others' access to the service (at use levels short of congestion), the marketplace is incapable of setting an equilibrium price for the service that would ensure its efficient level and use.[4]

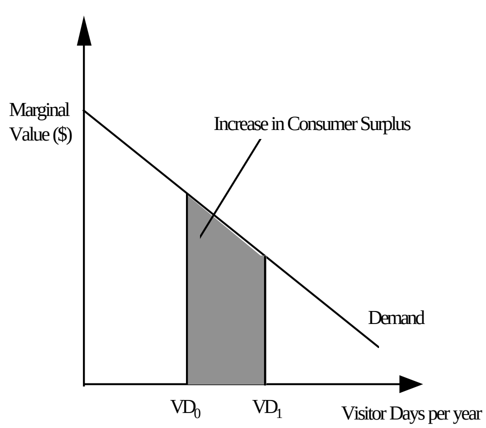
[4] Any non-zero price charged for a pure public service would be inefficient because it would discourage some use of the service, which is undesirable since the marginal cost of providing the service to additional users is zero (at use levels short of congestion).

Of course, absence of markets for ecosystem services does not mean they are not economically valuable. But absence of markets does mean that there are no observable market prices for ecosystem services that can be related to observed levels of service use in order to estimate the demand functions required for welfare measurement. To get around this problem, methods grounded in economic theory have been developed to estimate implicit prices associated with varying use levels for nonmarket goods. If the demand relationships for ecosystem services affected by Corps restoration projects could be empirically estimated, they could then be used to measure the net benefits of improvements in the supply or quality of these ecosystem services resulting from restoration. In this case, the welfare gain associated with an improved ecosystem service is measured by the change in the area under the estimated demand for the service bounded by zero if it is unpriced, or by the price of entry if an entrance fee is charged for access to the service.

To illustrate the benefits associated with a change in the *supply* of a collective ecosystem service, consider a lake restoration project designed to reduce nutrients in the water column by diverting additional, relatively nutrient-free, inflow streams into the lake. If this water diversion substantially increased lake size and shoreline, one immediate effect of the project might be to increase the amount of fishing activity the site could support. To facilitate the illustration of the resulting increase in fishing benefits, assume that the site is controlled by a public trustee which charges no entrance fee for public access to the site, but does limit public use of the site.

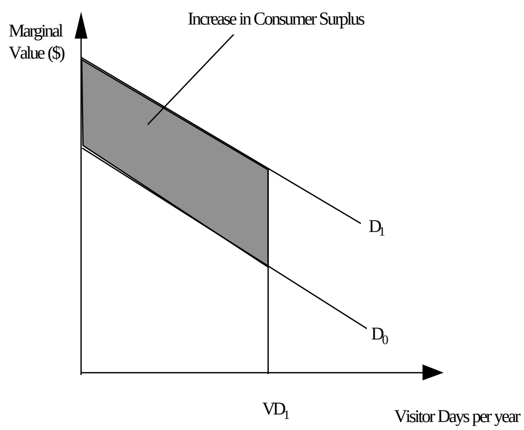
The welfare effects of this increase in fishing activity is illustrated by Figure 2.3. The demand function for fishing shows the marginal value (implicit price) of additional visitor days (VD) consumed per year. The pre-restoration supply of visitor days is represented by the vertical line at VD_0, which shows the annual limit on annual visitor days fixed by the public trustee. The lake restoration has the effect of increasing lake size and shoreline, enabling the public trustee to increase the limit on annual visitor days to VD_1. The additional fishing benefits resulting from the restoration project is approximated by the change in consumer surplus associated with the increase in visitor days, which is shown by the shaded area in Figure 2.3.

Figure 2.3 Welfare Effects of an Increase in the Supply of Recreational Fishing



Now consider the welfare effects of change in the *quality* of recreational fishing as reflected by, for example, an increase in catch rate per fishing day. This might occur in the lake restoration example given above when enough time has passed for the lake dilution to effectively reduce nutrient concentrations in the water, resulting in an increased stock of game fish. This is illustrated by Figure 2.4. The change in fishing quality at the site is reflected by a shift in the demand function for fishing from D_0 to D_1, which reflects the greater marginal value per fishing day for any given level of fishing days consumed. The welfare effects of this change in recreational fishing quality is reflected by the resulting change in consumer surplus, as represented by the shaded area between D_0 and D_1.

Figure 2.4 Welfare Effects of an Improvement in the Quality of Recreational Fishing



As discussed above, in order to estimate the net WTP for a change in the supply or quality of some ecosystem service, it is necessary to first estimate a demand function for that service.[5] The consumer surplus measure of net WTP discussed above is defined in terms of an "ordinary" (or Marshallian) demand function, which relates the quantity demanded of a good as a function of price and income. But the change in consumer surplus associated with a price change is an imperfect measure of the resulting welfare effect because substitution (purely price) effects are compounded by income effects.[6] Only substitution effects are

[5] The discussion to this point has referred to the market demand function to illustrate the concept and measurement of welfare change. The typical approach to benefits assessment, however, is to estimate a demand function for a representative user of the good which is used to assess changes in individual benefits. This estimate of individual welfare change is then aggregated across the entire population of users.

[6] The substitution effect represents the change in the quantity demanded of a good which results purely from a change in its price relative to the prices of other goods. So if the price of a certain good falls, thus making it cheaper relative to other goods, the substitution effect measures the degree to which a consumer will buy more of the good and less of other goods. The income effect, on the hand, represents the effect which a change in the price of a good has on the real income of the consumer, and through that, on his or her demand for the good. So if the price of a certain good falls, the income effect measures the extent to which the consumer will buy more of the good solely because of the resulting increase in real income.

relevant: The trade-offs that people make with respect to goods in the face of price changes is at the core of the economic theory and measurement of welfare change.

Use of the WTP measure of benefits based on estimated ordinary demand functions should be reasonable and appropriate for the ecosystem restoration context. The reader should be aware, however, that there are alternative measures of welfare change based on different treatments of income effects and resource entitlements. For a discussion of the theoretical bases and measurement of these alternative welfare measures, see Freeman (1993; Chapter 3).

2.5 Overview of Techniques for Valuing Ecosystem Restoration Benefits

In the ecosystem restoration context, various nonmarket valuation techniques are available for estimating monetary measures of improvements in the supply or quality of some types of ecosystem services as represented by the economic surplus provided to service users. For market commodities, this surplus can be estimated using observed information about the demand and supply for the particular good or service. But because of the nonmarket nature of most ecosystem services, demand information often is not directly observable. As a result, various techniques have been developed to measure the economic value of nonmarket goods and services, which can be grouped into three broad categories:

- Market approaches--which use observed (i.e. market) data for ecosystem goods that are traded in organized markets, or observed data for marketed goods that rely on nonmarket ecosystem services as productive inputs;

- Revealed preferences approaches--which use observed data on marketed goods that are used in conjunction with or otherwise linked to ecosystem services, and;

- Expressed preferences approaches--which elicit values for ecosystem services directly by getting people to state their preferences through money bids in hypothetical or constructed markets, policy referenda, or experimental settings.

The first category includes techniques that can take advantage of market-determined price and quantity information, as well as quantified data on ecosystem services. For example, the factor income/productivity technique measures the change in the value of output for a marketed good relative to the change in a (nonmarket) ecosystem service which serves as an intermediate input for the marketed good. In this case, benefits assessment focuses on measuring welfare effects in the market for the marketed good (see Figure 2.2 presented earlier).

Revealed preference approaches, such as hedonic pricing and travel cost models, use available information regarding individual purchase and consumption patterns for related market goods to develop demand functions for nonmarket ecosystem services. In this way individual preferences (demand) for changes in ecosystem services are revealed through their use of linked market goods, and can be used for benefits assessment (see Figures 2.3 and 2.4 presented earlier).

Finally, the expressed preference approaches, such as the contingent valuation method, elicit individual responses to a set of questions regarding preferences for ecosystem services in order to directly estimate benefits associated with nonmarket ecosystem services. This is the only available valuation approach for nonmarket ecosystem services which are not used in the production of or otherwise linked to marketed goods and services.

While each approach relies upon different information for measuring changes in economic surplus, they also emphasize different impacts associated with changes in the environment. Market approaches are suited to measuring value changes associated with ecosystem services that serve as productive inputs for marketed goods and services. These are services that contribute direct use values in production (see Table 2.1). For example, certain industrial operations use intake water for processing purposes. An ecosystem restoration project that increases the quality of this intake water could thus reduce industrial water processing costs.

Revealed preference approaches are applicable to ecosystem services that contribute to consumer utility through direct use. For example, ecosystem restoration can increase the benefits associated with consumptive recreational services (e.g. hunting) and non-consumptive recreation (e.g. nature study), as well as consumer benefits derived from locational amenities and aesthetics.

Expressed preference approaches, including the contingent valuation method and related techniques, could be used to measure the use values associated with any one or all of the services associated with some ecosystem, provided that these services could be adequately characterized for and understood by survey respondents. Moreover, the expressed preferences approaches are the only available measurement tools capable of estimating non-use (existence) values.

The valuation methods presented in this report include a representative from each of the three valuation approaches listed above. These techniques, which are summarized in Table 2.2 and discussed briefly below, include:

- Factor Income/Productivity Method (market approach),
- Travel Cost Models (revealed preference),
- Hedonic Property Value Method (revealed preference),
- Contingent Valuation Method (expressed preference), and
- Benefits Transfer (procedure for cross-applying valuation results developed for other sites).

Table 2.2 Summary of Valuation Techniques			
Technique	General Applications	Measurement Basis	Strengths/Limits
Factor Income/ Productivity	Can be applied to estimate use benefits of ecosystem goods that are sold directly in markets, and nonmarket ecosystem services that serve as factors of production for marketed goods.	Relies on estimating and using production relationships for the marketed good to estimate how changes in the ecosystem factor of production will affect the costs or profits of producers.	Major strength is that it avoids the need to model the demand side of the market. Major limitation is that the supply side modeling focus is reasonable only if the production unit in question is small relative to the overall production of the marketed good, or if the improvement in the ecosystem service represents only a marginal change.
Travel Cost	Can be applied to estimate use benefits of site recreational services, site quality attributes, and the introduction of new recreational sites.	Investigates changes in the quantities consumed of a complementary market good, travel to the site, to estimate the demand for nonmarket recreational services.	Major strength is that values are based on the actual choices of people. Major limitation is that region-wide modeling would generally be needed to estimate the welfare impacts of changes in site quality.
Hedonic Property Value	Can be applied to estimate use benefits of locational ecosystem amenities, aesthetics, and certain ecological services.	Investigates the prices of a complementary market good, residential property, to reveal the implicit prices of locational environmental attributes.	Main strength is that benefit estimates are based on the actual choices of people (in property markets that are relatively efficient in responding to information). Main limitation is that the scope of benefits that can be estimated is limited to the set of environmental services that can be captured by residents through their choice of residential location.
Contingent Valuation	Can be applied to estimate use benefits for any one or all ecosystem services, as well as nonuse benefits	Relies on the use of sophisticated surveys to obtain information from respondents on their preferences for ecosystem services.	Main strength is its flexibility which enables it to be applied to estimate use benefits associated with any one or all ecosystem services, as well as nonuse benefits. Major limitation is that responses to hypothetical questions may not reflect what people would actually pay for the resource in a real economic or policy choice setting
Benefits Transfer	Can be applied to estimate use benefits of recreational services, and perhaps other ecosystem services.	Relies on valuation results for some site derived in a previous study (unit value estimates or valuation models) to develop benefit estimates for the restoration project site.	Main strength is that it is can be implemented relatively quickly and inexpensively. Main limitation is that, because resource values are region/site/user specific, benefit transfers can provide only gross approximations of benefits at project sites.

The *Factor Income/Productivity Method* is a market-based approach that can be used to estimate the commercial value of ecosystem outputs that are sold directly in markets (e.g. fur-bearing animals harvested for their pelts) or, more typically, nonmarket ecosystem services that serve as inputs into the production of marketed goods (e.g. intake water for industrial production; irrigation water for agriculture; food chain and habitat support for commercial fisheries). The technique is applicable when it can be assumed that the change in the ecosystem service which serves as a factor of production for a final marketed good will not affect the output price of the final good or the prices of other factor inputs. Given this assumption, the benefits of an improvement in the ecosystem factor can be measured by the expected change in profits accruing to producers of the marketed good. Application of the technique typically involves developing a model of the production process for the marketed good which relates all variable production inputs, including the ecosystem inputs, to the output of the marketed good. This production model can be then used together with data on the price of the final marketed good to estimate benefits associated with a marginal change in the ecosystem input. The technique is also applicable for estimating how ecosystem improvements might affect the cost of producing a given level of output for a final good. For example, if ecosystem restoration resulted in less dredging needs for a hydroelectric facility, the economic benefits of this would be reflected in lower production costs.

Travel Cost Models can be used to estimate the benefits associated with site recreational services, and can also be extended to estimate value changes resulting from improvements in site attributes (e.g water quality) that affect the quality of site recreational services. A characteristic common to all travel cost applications is that visitors from various locations visit a common site, and thus bear different costs to enjoy the same good. Travel cost models use observed data on changes in the consumption of this complementary good (travel to a site) to estimate a demand relationship from which values for recreational services can be inferred. Specifically, a demand function for recreation is estimated by modeling the relationship between site visits and travel cost. Site quality can be represented by a variety of characteristics that must be defined for the study site (as well as possible substitute sites) and included in the model. These quality measures can be based on objective data, such as dissolved oxygen concentration or fecal coliform levels in a water body, or by some measure of perceived quality based on interviews of site visitors. Assessment of the benefits associated with a change in site quality can then be modeled by estimating the resulting shift in demand for recreation at the study site.

Hedonic pricing models are used to infer the demand for environmental quality attributes through the analysis of marketed goods whose value depends in part on these attributes. The technique is based on the hypothesis that since consumers ultimately derive utility from the characteristics of goods, the prices paid for certain marketed goods are directly related to the nature and supply of these attributes. The *Hedonic Property Value Method*---the particular hedonic method presented in this report--relies on variations in residential property values to reveal implicit prices for environmental amenities. These implicit price estimates can then be used to approximate amenity demands. In the ecosystem restoration context, the hedonic property value method may be useful for estimating the value of improvements in aesthetics and other locational amenities that directly contribute to consumer utility. The method can also be applied to estimate the value of improvements in certain ecological services, such as flood control, which contribute to the utility of affected populations in a more indirect way.

The *Contingent Valuation Method* involves an analysis of individuals' responses to hypothetical survey questions which elicit information on preferences for specific changes in ecosystem attributes or service flows. Depending on the questioning format, responses may provide direct expressions of resource values or other information on preferences from which benefits estimates can be derived. This technique could be used to value improvements in any one ecosystem service or all services together. Moreover, it is the only technique capable of estimating nonuse (existence) values that people might place on the improvement of ecosystem structure and functions (e.g., biodiversity) and associated service flows.

Benefits Transfer is not a valuation technique but rather a procedure that involves applying a monetary value estimate or estimated demand or value function developed for some site in a previous study to the ecosystem being considered for restoration. This type of benefits transfer might be particularly useful for ecosystem services such as recreation and aesthetics previously estimated using revealed or expressed preference approaches.

As the previous discussion suggests, the various techniques outlined above are applicable for estimating the welfare effects of changes in virtually all major ecosystem services that contribute direct use values in production or consumption, as well as non-use values. However, they may not be as applicable to ecological outputs such as flood control and sediment retention which indirectly contribute to consumer utility and producer profits. In some cases it may be possible, for example, to assess the benefits of reduced sedimentation for specific commercial or industrial processes using the factor income method, or to measure the residential value of increased flood protection using the hedonic pricing method. However, the linkages between ecological services and economic value are often too indirect and non-specific to assess their benefits using market or revealed preference approaches. And the contingent valuation technique may not provide reliable value estimates for nonmarket ecosystem services for which people are unfamiliar and have no experience trading off for other goods.

To get around these limitations of the WTP-based valuation techniques, two alternative techniques--the *Least Cost Alternative* (LCA) and the *Property Damages Avoided* (PDA) methods--have sometimes been used to value certain ecological services. The LCA method is based on the economic definition of opportunity costs, which says that the costs of using resources is equal to the benefit these resources would have provided in their next best alternative use. In the ecosystem restoration context, the LCA method measures the cost savings to consumers associated with not having to use other resources to obtain the same project output. For example, use of the LCA method to value the improved flood control service provided by an ecosystem restoration project might focus on estimating the costs averted by not having to invest in structural flood control measures that would provide the same human benefits.

The PDA method is conceptually very similar to the LCA method, but approaches the valuation task from a different perspective. It measures the benefits of ecosystem services based on the dollar value of property damages that would be expected to result from not having the service (and thus assumes that no alternative means of providing the same ecosystem service would be undertaken if the restoration project were not). For example, to value the flood reduction service that would be provided by a restoration project, it would estimate and put a dollar value on the expected property damages averted.

The ability of these two alternative techniques to produce benefit estimates consistent with the WTP concept of value is limited, however, because they focus on the supply side of the service without considering the public demand for it. For example, in order for the LCA to provide an accurate measure of WTP, two restrictive conditions must hold: 1) the least cost alternative to the ecosystem service (e.g. structural flood control measures) must provide the same level of service that the restoration project would provide, and 2) there must be evidence which suggests that the alternative would actually be undertaken if the restoration project were not. The second condition might sometimes hold in cases where, for example, localities face legislative mandates to implement storm water control measures. In such cases the LCA may provide reasonable estimates of WTP for the ecosystem service as long as the alternative means being considered is the least expensive option, and would provide a comparable level of the output as the ecosystem service.

The PDA method also is not based on the demand for ecosystem services. In the flood control case, for example, its ability to approximate WTP depends largely on the assumption that repairs would actually be made for flood damages that would be expected in the absence of the restoration project. But affected populations might not value flood damages highly enough to actually pay for all needed repairs; they instead may prefer to take some limited measures to avert possible flood control damages, and then undertake repairs for only some of the flood impacts that do occur. The PDA method is thus hypothetical (because no post-flood repair choices are actually observed) and can produce results that do not conform very well to actual WTP.

Although their ability to produce value estimates consistent with the WTP concept is limited, Corps planners have a long history of using these two techniques for civil works planning in recognition of their limitations as valuation tools. And these methods might have some potential application for estimating certain ecosystem restoration benefits (e.g. flood control) that might not be amenable to estimation using the WTP-based methods. Use of the these methods in the ecosystem restoration context faces no more analytical demands than that typically encountered in the traditional civil works planning context, and Corps procedures manuals are available to guide their application (see: Johnson, et al, 1988; Mills, et al., 1991). Consequently, these methods are not considered further in this report.

2.6 Summary of Resource Requirements for Valuation Techniques

As part of this study, an informal survey of academic economists with experience applying the economic benefits assessment techniques discussed in this report was undertaken. These practitioners were asked to supply information on their involvement in specific studies which applied the techniques in the water resources and restoration context, with particular attention to the resources that were required to implement the techniques given the level of sophistication and geographic scope of the studies. This information was gathered to assist Corps planners in their need to identify the practicality of implementing the various techniques for ecosystem restoration planning and evaluation.

Table 2.3 provides a summary of the resources required for implementing the valuation techniques in the ecosystem restoration context based on the survey results. For each technique, the table provides summary information on:

- **Data.** Identifies the major data requirements for implementing a study using the technique.

- **Expertise.** Identifies the expertise required to implement the technique in a timely, technically competent, and cost-effective manner.

- **Cost Range.** Identifies a range for the expected costs of performing a study using the technique in the ecosystem restoration context.

- **Time Range.** Identifies a range for the time required to complete a study using the technique in the ecosystem restoration context, which includes that needed to obtain the necessary data and perform the analysis.

- **Comment**. Identifies the major assumptions used to produce the estimates for the costs and time required to implement the technique. These assumptions concern the level of technical sophistication and data needs and availability, including the form and scope of required surveys.

In general, the economic benefits assessment techniques discussed in this report are data intensive and in many applications would require primary data gathering through surveys. With regard to required expertise, application of the techniques typically requires advanced training in economic theory, statistics and econometrics, and applied data management and analysis. And those techniques that rely on primary surveys to obtain needed data also require researchers skilled in survey design and sampling procedures. These considerations, and related study cost and time factors discussed below, suggest that the use of these techniques for ecosystem restoration planning might be limited to large-scale and complex restoration projects involving multiple and otherwise non-commensurable environmental outputs, or particular outputs associated with large and estimable economic benefits. In such cases the use of benefits assessment techniques could help to reduce the number of non-commensurable trade-offs needed for project evaluation by expressing one or more restoration outputs in economic terms commensurable with project costs.

The costs and time required to apply a valuation technique are primarily a function of two variables: 1) degree of technical sophistication, and 2) data availability and accessibility. Each of the techniques can be implemented with varying degrees of technical sophistication, and as sophistication increases, implementation cost and study time rise. And at any level of technical sophistication, study time and cost will be affected by the skill and ingenuity of the researchers.

Since the valuation techniques are all data intensive, data availability and accessibility are also major drivers of study time and cost. One important factor concerns whether primary data gathering is needed to implement a technique. For example, if databases on property prices and lot characteristics are available and computer accessible, the costs and time needed to perform an

Table 2.3 Summary of Resource Requirements

Technique	Resource Requirements in the Ecosystem Restoration Context				
	Data	Expertise	Cost Range	Time Range	Comment
Factor Income/ Productivity	Production and price data for the final marketed good and data on the levels of factor inputs used, including the ecosystem factor input	Advanced knowledge of production theory and econometric methods; working knowledge of renewable resource or engineering models	$30-50 thousand	2-4 months	Cost and time estimates assume that the necessary data are readily available and the main task involves conceptualizing and empiricizing the model
Travel Cost	Data on user visits, characteristics, and distance traveled to regional recreational sites; data on the services provided by and characteristics of regional sites.	Advanced knowledge of demand theory, statistics and econometrics, survey design and sampling procedures	$50-150 thousand	1-2 years	Cost and time estimates assume that regional modeling is needed to obtain the necessary variation in measures of site quality, and to account for possible substitutes. The low ends of the ranges assume that most of the needed data are available and accessible from secondary sources; the high ends assume that primary data gathering using site intercept surveys would be required
Hedonic Property Value	Data on property prices, lot and neighborhood characteristics, and locational environmental attributes	Advanced knowledge of demand theory, statistics and econometrics; skilled data manager	$30-50 thousand	4-6 months	Cost and time estimates assume that the needed data are readily available and computer accessible
Contingent Valuation	Random sample survey of relevant population	Advanced skills in survey design, sampling procedures, and data management; advanced knowledge of demand theory, statistics and econometrics	$50-100 thousand	6-12 months	Cost and time estimates assume use of a relatively sophisticated questioning format, a mail or telephone survey (or on-site, personal interviews), and a modest sampling level (200-400 sample members)
Benefits Transfer	Data on unit value estimates or valuation models from existing studies. Data on the characteristics of project sites, and the number and characteristics of project site users	Advanced knowledge of nonmarket valuation methods, demand theory and econometrics (required expertise may not be as great as that needed to implement primary studies)	$10-20 thousand	1-3 months	The low ends of the cost and time ranges assume use of a unit value transfer and the availability of secondary data on project site users; the high ends assume use of model transfers and some primary data gathering on the number and characteristics of site users

hedonic property value study will be much less than if the researcher had to rely on individual land records to get the needed data. Similarly, the Corps routinely collects visitation data at Corps reservoirs. Thus, the examination of the recreational benefits associated with restoring lakes at these sites might avoid the need for primary data gathering.

Many of the valuation techniques would typically require at least some primary data gathering through surveys, and some rely wholly on survey data. A number of survey factors can greatly affect study time and cost, including the survey administration technique used and the survey sample size. The most important of these for study time and cost is probably the survey administration technique employed. Surveys can be conducted through the mail, by telephone, and through the use of at-home, personal interviews or site-intercept interviews (e.g. traffic stop surveys at recreational sites), and the cost for these different methods can vary by a factor of twenty or more. Costs for mail surveys can range from \$10-20 per sample member, which includes expenses for printing, mailing and distribution, and follow-up post card or telephone reminders. Telephone surveys can cost \$20-30 for a 15-25 minute interview. At-home personal interviews can cost \$100 per interview or considerably more if interviews are hard to arrange and complete.

Study time can also be influenced by the seasonality of the types of data that must be collected through primary surveys. For example, the implementation of a travel cost study using primary, on-site survey data might require observations over several recreational seasons. But it might be difficult or impossible to collect the necessary data within the time frame in which the study must be completed.

Finally, it should be recognized that the two main drivers of study time and cost discussed above are never fixed, and will in large part be determined by the need for precision in any valuation study. In large-scale and high-profile restoration projects such as that involving the Florida Everglades, for example, a high level of precision might be a priority, which would dictate the use of relatively sophisticated methods and careful surveys with large sample sizes and response rates. In the general restoration context, however, a relatively modest level of technical sophistication and data levels may be sufficient. Consequently, the range estimates given in Table 2.3 for application costs and time are based on certain assumptions regarding the level of technical sophistication, availability of secondary data, and the form and scope of needed surveys. These assumptions were employed in order to tighten the ranges to reflect the ecosystem restoration context. It should be recognized, however, that if the actual application settings for these techniques did not mirror these assumptions, study times and costs could easily fall outside of the given ranges.

2.7 References

Braden, J.B. and C.D. Kolstad (eds). 1991. *Measuring the Demand for Environmental Quality*. North-Holland. Amsterdam.
This book provides a comprehensive review of the state-of-the-art in the theory and measurement of the demand for environmental goods and services, including assessments of the relative strengths of the various available methods for evaluating preferences for important classes of environmental goods and services. It is intended to be a reference for graduate students and practitioners in the field.

Cole, R.A., J.B Loomis, T.D. Feather, and D.F. Capan. 1996. *Linkages Between Environmental Outputs and Human Services*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 96-R-6.
This report, which was prepared as part of the Corps "Evaluation of Environmental Investments Research Program", identifies links between the various ecological effects of ecosystem restoration projects and their socioeconomic impacts which give rise to social value.

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values: Theory and Methods*. Resources for the Future. Washington, DC.
This text provides a comprehensive review and assessment of the state-of-the art in the theory and measurement of environmental and natural resource values. The material is geared toward economics graduate students and practitioners in the field.

Johnson, N.B., W.J. Hansen, J. Warren, F.R. Reynolds Jr., C.O. Foley, and R.L. Fulton. 1988. *National Economic Development Procedures Manual--Urban Flood Damage*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 88-R-2.
This report provides an expanded description of the urban benefit evaluation procedures recommended by the Water Resource Council's *Principles and Guidelines*. The report present specific procedures for the entire process of urban benefit estimation and is intended for use in project feasibility planning and evaluation.

Mills, A.S., S.A. Davis, and W.J. Hansen. 1991. *National Economic Development Procedures Manual--Urban Flood Damage, Volume II*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 91-R-10.
This is the second in a series of manuals designed to provide procedures and techniques to measure flood damage and to further implement the U.S. Water Resource Council's *Principles and Guidelines*. This manual is a primer for conducting comprehensive flood damage and related surveys.

Robinson, R., W. Hansen, K. Orth, and S. Franco. 1995. *Evaluation of Environmental Investments Procedures Manual, Interim: Cost Effectiveness and Incremental Cost Analyses*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 95-R-1.
This manual, which was prepared as part of the Corps' "Evaluation of Environmental Investments Research Program", serves as a guide for conducting cost effectiveness and incremental cost analyses for the evaluation of alternative environmental restoration and mitigation plans. It presents a procedural framework for conducting the cost analyses and discusses how they fit into, and contribute to, the Corps' planning process.

Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington, DC.
This manual establishes the appropriate concepts, procedures, and techniques for analytical studies conducted by the Corps to evaluate the National Economic Development benefits of civil works plans.

3. FACTOR INCOME/PRODUCTIVITY METHOD

3.1 Introduction

The factor income/productivity method is a market-based technique that can be used to estimate the benefits associated with augmented ecosystem goods that are sold directly in markets (e.g. fur-bearing animals harvested for their pelts) as well as nonmarket ecosystem services that serve as factors of production for marketed goods (e.g. water input for municipal drinking water supply; food chain and habitat support for commercial fisheries). In either case the ecosystem is used together with capital, labor and other variable inputs to produce a marketed good. The factor income/productivity method relies on estimating and using these production relationships to estimate how changes in the ecosystem factor of production will affect the costs or profits of the producers of the final marketed good. The method is thus applicable when it can be assumed that the benefits associated with the ecosystem contribution to the production of the marketed good will accrue solely to producers of the good.

The method is useful in two situations relating to ecosystem restoration. The first is when it can be assumed that improvements in the ecosystem input will increase output of the marketed good, the benefits of which will accrue solely to producers in the form of increased profits (i.e. producer surplus). For example, if wetland restoration increases food chain and habitat support for commercial fish species, and this in turn results in increased commercial fish landings for any level of fishing effort, the resulting increase in commercial fishing profits can be used as one measure of the benefits of wetlands restoration. Importantly, use of profits as a measure of benefits depends on the assumption that the ecosystem improvement will not result in changes in the market price of the final marketed good or the prices of other factor inputs.

The second situation is when the ecosystem factor input is a perfect substitute for other factor inputs used to produce a final marketed good, and an increase in the quantity or quality of the ecosystem input will reduce the costs of producing a fixed level of the marketed good. For example, if ecosystem restoration leads to reduced dredging needs for a hydroelectric facility, the reduction in dredging costs represents a measure of the benefits of reduced sedimentation. Similarly, if improved water quality results in less chlorination requirements for a drinking water treatment plant, and the substitution relationship between water quality and chlorination needs is known, the benefits of improved water quality can be calculated as reduced chlorination costs. Importantly, use of decreased production costs as a measure of the benefits of ecosystem improvements assumes that the change in total production costs will not affect marginal cost and output of the marketed good (Freeman, 1993; p. 97).

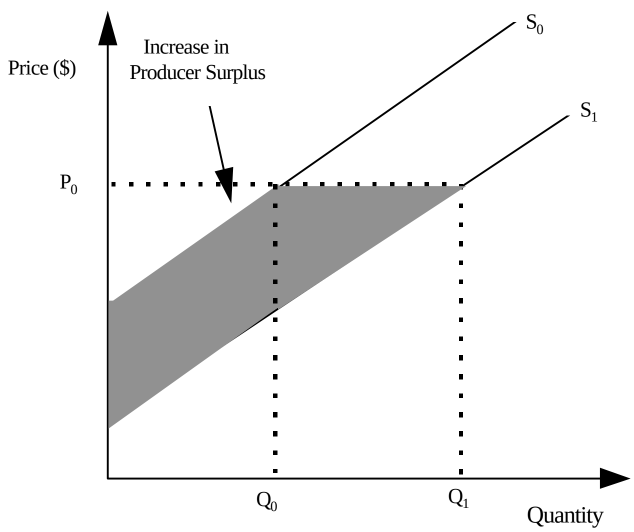
3.2 Theoretical Basis for Technique

The factor income/productivity method relies on modeling the relationship between factor inputs and output of the final marketed good. For example, a simple production function for a marketed good, Q, with only two factor inputs--capital (K) and labor (L)-- where $Q = f(K,L)$, shows the amount of the good that can be produced using alternative combinations of K and L. If environmental quality (ENV) also contributes to the production of Q, then it is an exogenous variable that also enters the production function, so that Q = *f*(K,L,ENV). Specification and statistical estimation of this production relationship yields parameter estimates that represent the marginal physical contribution (or marginal product) of each factor input, including environmental quality, to the production of the marketed good. The marginal product of a factor input represents the contribution of the last unit of that input used in the production of the marketed good.[7] This measure multiplied by the price of the marketed good corresponds to the value of that last of unit of factor input employed, and thus can be used to measure the benefits associated with small changes in that factor input.

As an example, consider the case of a coastal wetland that provides nursery habitat for a commercially exploited, marine fishery. If a restoration project increased the quantity and quality of wetlands, thus increasing the stock of fish, this in turn would increase fishery productivity for any level of fishing effort.

This case can be modeled as a shift in the market supply curve, as depicted by Figure 3.1. In this diagram, Q_0 represents the quantity of fish harvested before wetlands restoration. The increase in wetlands after restoration results in an outward shift in the supply function, and an increase in the quantity of harvested fish to Q_1. The shaded area between the two supply curves represents the increase in producer surplus (i.e. commercial profits) resulting from the increase in wetlands provided by restoration.

Figure 3.1 Increase in Producer Surplus Resulting from an Increase in Supply



[7] The marginal product (MP) of each factor input is the additional output that can be produced by employing one more unit of that input while holding all other inputs constant. Mathematically, $MP_{ENV} = dQ/dENV$.

3.3 Application of Technique

In order to estimate the benefits to commercial fisheries provided by wetland restoration as in the example given above, it is necessary to specify and estimate a production function for the commercial fishery that relates harvests to two general factors of production: (1) fishing effort, and (2) the level of wetlands. To capture the contribution of wetlands to fish harvest, a bio-economic production function might be needed which incorporates a biological population (growth and mortality) model for the commercial fish species. This biological model would form the basis for specifying a production function that makes the fishery harvest a function of economic inputs (human fishing effort), and level of wetlands (through its effect on the stock of fish). The estimated bio-economic production function could be used to isolate the marginal contribution of wetlands to the fishery. This marginal contribution, together with data on market prices for fish, could then be used to estimate the change in commercial fish profits associated with small changes in wetlands stock.[8] The general approach outlined above would involve the following steps:

- Assemble historical time series data on fish landings, fishing effort, and natural system services (i.e. wetlands) for the relevant region.

- Specify the production relationship which includes measures of effort for the fishery examined and natural system services, and defines the way in which they contribute to production.

- Estimate the production function by, for example, regressing the total annual fish landings against fishing effort and levels of natural system services.

- Use the estimated coefficients from the regression model to estimate the contribution of natural system services to fish harvest over a range of increases in these services.

- Use the results of step 4 and the market price for the commercial fish species of interest to estimate area-wide changes in commercial fishing benefits from enhanced natural system services resulting from ecosystem restoration.

A number of applications of the method to value wetlands contribution to commercial fisheries in the manner described above have been reported in the literature. For example, Batie and Wilson (1978) examined the value of wetlands for oyster propagation by developing a production function for harvested oysters in Virginia that was specified as a function of effort, number of acres of leased oyster ground, number of acres of open access property oyster grounds, number of wetland acres, a salinity variable, and a time variable. The estimated model was then differentiated with respect the wetlands variable to estimate the marginal product of wetlands. This estimate was then multiplied by the dockside price of oysters to calculate the marginal contribution of wetlands to the oyster fishery.

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[8]Estimation of welfare changes in a commercial fishery depends on the regulatory framework of the fishery. In the case of a managed fishery, welfare changes would appropriately be estimated based on changes in marginal productivity. If commercial fishermen operate in a largely unregulated, open access environment, however, then welfare measurement would appropriately be estimated based on changes in average rather than marginal productivity.

Similarly, Lynne et al. (1981) used this approach to value coastal wetlands as an input in the production of blue crabs in Florida. They started with a biological model of crab growth in which the maximum potential biomass in a given year was specified as a function of the quantity of marsh in the previous year. The biological model was combined with an equation that related catch proportionally to the biomass effort in a given year requiring that in “steady state” catch must equal growth. This represented a bio-economic production function explaining catch as a function of the quantity of marsh and human effort expended to harvest crabs. The model was estimated using twenty years of time series data on blue crab catch rates, levels of fishing effort, and estimated marsh levels. The estimated function was differentiated with respect to the marsh variable to derive an estimate of the marginal productivity of marsh for producing crabs, which was then multiplied by the exvessel price of crabs to derive the marginal value of an acre of marsh.

Use of the factor income/productivity method to estimate changes in production costs for a given level of output for a marketed good, also begins with the specification and estimation of a production function which relates factor inputs, including the ecosystem input, to the production of the final marketed good. For example, the production of treated drinking water would be related to the quality of intake water, chlorination requirements, as well as other fixed and variable inputs. An estimated production function for potable water supply could be used together with data on factor prices to estimate the costs of producing a given level of output for the marketed good. If the production function embodies information on the marginal rate of technical substitution between water quality and chlorination requirements, the benefits associated with an improvement in water quality could then be derived in the form of reduced chlorination costs.

3.4 Strengths and Limits

The major strength of the factor income/productivity method is that it is a relatively simple and straightforward method for estimating the benefits associated with ecosystem services that contribute to the production of marketed goods. Its relatively simplicity lies in its modeling focus on the supply side only of the marketed good. But this limited modeling focus is reasonable only if it can be assumed that the change in the ecosystem input will not in turn change the price of the marketed good or the prices of other factors of production. This assumption may be realistic if the production change is small relative to the overall production of the marketed good, or if the change in the ecosystem input represents only a marginal change. For example, in the examples given above for commercial fisheries, nonmarginal changes in regional wetlands stock would be expected to alter the costs of harvesting any level of fish, leading to changes in price and output. In this case, market analysis going beyond the factor income/productivity method is necessary to estimate welfare changes to both producers and consumers of the marketed good. The same is true for use of the technique to estimate changes in total production costs for a marketed good. As long as output of the marketed good remains constant after the improvement in the ecosystem input, the reduction in production costs is a true measure of benefits. However, if the change in the ecosystem input affects the marginal costs of producing the marketed good, the welfare effects will include the effects of lower costs on output and price.

Another limitation of the method is that it can only be used to capture the contribution of environmental services to marketed goods. To the extent that these same environmental services also contribute to social welfare in other, nonmarket ways, use of the technique will underestimate their total social benefits.

3.5 Resource Requirements

The primary resource requirement and constraint for application of the method is getting the needed data, particularly that for the environmental variable. To utilize this method, there must be sufficient information to document the level of services provided by a natural resource as a production input. As long as the needed data are available and readily accessible from secondary sources, the technique can be relatively simple and inexpensive to implement. With the necessary data, resource requirements will primarily involve conceptualizing the model, which requires graduate knowledge of production theory and a working knowledge of bioeconomic models of natural resources. Given available data and technical expertise, the technique could probably be applied by one researcher working full time for two to four months at a cost of $30-$50 thousand. But if the data were difficult to find and obtain, or the model was very difficult to conceptualize and empiricize, study time and cost could be significantly more.

3.6 References

Batie. S.S. and J.R. Wilson. 1978. "Economic Values Attributable to Virginia's Coastal Wetlands as Inputs in Oyster Production". *Southern Journal of Agricultural Economics*. 1:111-118.
This article reports the results of a study which used the factor income/productivity method to estimate the value of wetlands for oyster fisheries. The study estimated a production function for oyster harvest in Virginia that related harvest to human fishing effort, wetland area, oyster grounds, and other explanatory variables. The parameter estimate for the wetlands variable was multiplied by the dockside price of oysters to calculate the marginal contribution of wetlands to the fishery.

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future. Washington, DC.
This text provides a thorough review of the current state of the art of the theory and practical application of resource valuation techniques. The factor income/productivity method is discussed in Chapters 4 and 9.

Lynne, G., P. Conroy, and F. Prochaska. 1981. "Economic Valuation of Marsh Areas for Marine Production Processes." *Journal of Environmental Economics and Management*, 8: 175-186.
This articles reports a study which estimated a bio-economic production function relating blue crab harvest in Florida that explains catch as a function of the quantity of wetland marsh and human fishing effort. The estimated parameter for the wetland variable was used together with data on the exvessel price of crabs to derive a marginal value for an acre of marsh in the production of blue crabs.

4. TRAVEL COST MODELS

4.1 Introduction

Travel cost models are a class of valuation techniques developed for estimating site recreational benefits. They are based on the observation that visits to recreational sites involve an implicit transaction--the costs of traveling to a site are incurred in return for access to the site's recreational service flows. The travel cost method relies on the observation that visitors to a site incur different costs to get there, depending primarily on the distance traveled. Relevant costs, including the outlay of time and travel expenditures, reflect an implicit price of the recreational services provided by the site. The relationship between quantity demanded (e.g., number of visits per season) and price, measured by travel costs to the site, is estimated to construct a market demand curve for the site. The area under the demand curve approximates the total recreational benefits provided by the site. The model can also be extended to incorporate site quality variables in order to estimate how changes in site attributes affect site benefits. Implementation of the method to estimate site recreational benefits associated with ecosystem restoration requires that:

- There is sufficient variation in travel costs among users to allow estimation of site demand,
- Site visitors' travel expenses are incurred solely for the purpose of recreation at the study site,
- The proposed changes to the site are significant enough to alter travel cost for some individuals, or to alter the number of trips that will be made at the existing travel cost, and
- These changes in the number of trips can be observed using available cross-sectional or time series data (Vincent, et al., 1986).

Ecosystem restoration can affect recreational services and their associated benefits by: 1) increasing the capacity of an existing recreation site (e.g. the number of activity days supportable), 2) improving the quality of recreational service flows provided by an existing recreational site, or 3) creation of a new recreation site. As will be discussed further below, there are various different travel cost approaches that have differing abilities and limitations for estimating the differing ways in which ecosystem restoration can potentially affect recreational services and benefits.

4.2 Theoretical Basis for Technique

Travel costs models are a form of the "Household Production Function Approach" which holds that the value of certain nonmarket goods is indirectly reflected in the consumption of market goods that are substitutes or complements for the nonmarket good. Travel cost models investigate changes in the quantities consumed of a complementary market good, travel to the site, in order to estimate demand for a nonmarket good, site recreational services. Importantly, travel to a site can be used to infer the demand for a recreational site only if it is a necessary part of the site visit, or in the vernacular of economics, is "weakly complementary" to site recreation. The key assumption of the model is that travel costs are a suitable proxy for individual utility gained through visiting a recreational site. If visitors do no consider travel costs, or travel costs are embedded in other trip objectives, the welfare measure provided by the model has no significance.

There are varying approaches to modeling recreator choices with respect to recreational sites in response to differences in travel costs. These modeling approaches can be grouped into two broad categories based on the temporal perspective of the travel decision:[9]

- Perspective 1 -- Over the course of a recreational season or year, recreators choose the number of trips to the study site (and perhaps other sites), and
- Perspective 2 -- At a specific point in time, individuals choose (a) whether to visit a recreational site, and if so (b) which site will they visit.

Recreator choices involving the temporal dimension given by Perspective 1 are modeled using the continuous single (or multi) site travel cost method. The relationship between travel costs (price) and number of trips (quantity) is exploited to estimate a demand curve for the site. The dependent variable in this model is the number of trips over some time period. In the zonal travel cost model, for example, observed visits to a site are pooled for various zones of origin (e.g., towns or cities) at different distances from a site. Zonal visitation rates are regressed on a set of explanatory variables such as travel cost, socioeconomic characteristics of visitors, and site attributes in order to derive a demand curve for the site. The area under the demand curve represents the value of the flow of services from the site, aggregated across all individuals who use the site.

To estimate how changes in site quality will affect recreation benefits, it is necessary to include in the model explanatory variables for site quality attributes with the variation necessary for estimating quality coefficients. Then if it can be determined how the quality variable will change with restoration, pre-and post-restoration demand curves can be estimated for the site, and the area between these demand curves can be used to approximate benefits associated with the change in site quality

Individual choices involving the temporal dimension given by Perspective 2 are modeled using random utility models, which are discrete choice rather than continuous models. Unlike the travel cost method, the random utility model does not focus on measuring demand functions for recreational sites. Instead, an indirect utility function is specified and estimated directly from individual choice observations, and then used directly to estimate welfare measures.[10] Variables in the indirect utility function include travel costs, site quality, income and other socioeconomic characteristics of the potential recreators. These variables affect the probability of an individual recreator choosing to visit a site or the probability of choosing one site over another. The parameters of the indirect utility function are used to calculate individuals' welfare values, which are aggregated across all site visitors to estimate the value of the site. The welfare effects of changes in site quality can be estimated directly because the characteristics of the site are included as variables directly in the indirect utility function.

The different travel cost models that flow from these alternative temporal perspectives for the recreation choice decision have differing strengths and limitations for estimating the welfare effects

[9]This section and the next relies heavily on Freeman (1993), Chapter 13.

[10]A utility function maps individuals' preference for the consumption of a bundle of goods. The indirect utility function maps these preferences for a given income level and commodity prices.

associated with the types of impacts on recreational service flows likely to be associated with ecosystem restoration. The single site travel cost model focuses on measuring site recreational demand, and thus is most useful for explaining the total number and value of site visits during a recreational season. If a restoration project increased the number of site user days a recreation site could support, the value of this could be estimated using the demand function derived from the continuous travel cost model.

Use of the continuous travel cost model to estimate the welfare effects of changes in the quality of recreational sites--probably the most common effect of ecosystem restoration projects on recreational service flows--is more problematic. The biggest problem for estimating the benefits associated with changes in site attributes using the continuous travel cost model involves obtaining and incorporating into the model meaningful data on site quality that has the variation necessary for estimating quality parameters and for predicting the welfare effects of post-restoration outcomes.

The random utility model, with its attention to how people choose among quality-differentiated substitute sites for any given recreational trip, is better suited for assessing the benefits of improvements in site quality. However, by itself, the model cannot explain the total number of trips that an individual makes to a given site in a season. For this reason, it is often necessary to estimate in conjunction with the model a continuous demand function for trips to all sites which can be used to explain the proportional allocation of the total number of trips over different sites. The random utility model can also be used to estimate the benefits associated with the creation of new recreational sites which may result from ecosystem restoration.

4.3 Application of Technique

The construction of a site demand curve using the zonal travel costs method is illustrated in the following hypothetical example (as reported in Hufschmidt et al., 1982). In this example, it is assumed that use of the recreational area is free. People arriving at the site are interviewed to obtain the information described above. Information on the population of visitors from each zone, average travel costs, and number of visits made per year is provided in Table 4.1.

Table 4.1 Visitors to Hypothetical Recreational Area

Zone	Population	Avg Travel Cost per Visit ($)	Number of Visits	Visits/1,000 population
1	1,000	10	400	400
2	2,000	30	400	200
3	4,000	40	400	100
Beyond 3			0	
Total Visits			**1,200**	

The number of visits per capita can be plotted against the average travel cost per visit using the data presented in Table 4.1. This relationship is represented by the following equation:

$$V/1{,}000 = 500 - 10C$$

where V/1,000 is the number of visits for every 1,000 persons and C is the travel cost per visit. After determining the visitation rate-travel cost relationship, this equation is then used to simulate the effect that an entrance fee would have on individual's choice to visit the site. Assuming a $10 entrance fee to the site, Table 4.2 below shows the change in visitation rates for each of the relevant travel zones.

Table 4.2 Visits to a Recreational Area Assuming a $10 Entrance Fee

Zone	Travel Cost ($) + $10 Entrance Fee	Visits/1,000 population	Population	Number of Visits
1	20	300	1,000	300
2	40	100	2,000	200
3	50	0	4,000	0
Total Visits				**500**

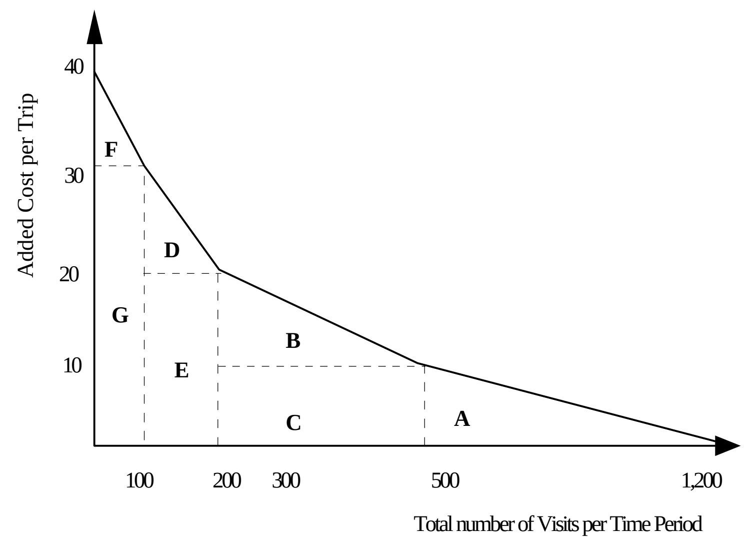
This process is repeated with further increases in simulated entrance fees until the total number of visits to the site is zero. The demand curve estimated using this technique is illustrated in Figure 4.1.

The first point on the demand curve ($0 entrance fee; 1,200 visitors) was calculated in Table 4.1. The next point ($10 entrance fee, 500 visitors), was calculated in Table 4.2. Using the same approach, the final three points on the demand curve are calculated:

- $20 entrance fee, 200 visitors,
- $30 entrance fee, 100 visitors, and

- $40 entrance fee, 0 visitors.

Figure 4.1 Demand Curve for a Recreation Area



Total consumer surplus for the recreational area can be calculated from the area under the demand curve presented in Figure 4.1:

[(1,200-500)/2]*$10	=	$ 3,500	(area A)
[(500-200)/2]*$10	=	$ 1,500	(area B)
[500-200]*$10	=	$ 3,000	(area C)
[(200-100)/2]*$10	=	$ 500	(area D)
[200-100]*$20	=	$ 2,000	(area E)
[(100-0)/2]*$10	=	$ 500	(area F)
[100-0]*$30	=	$ 3,000	(area G)
Total	=	$14,000	

This recreational site has a recreational use value of $14,000 per year, or $14,000/1,200 = $11.70 per on-site visit.

This basic procedure for deriving a demand curve using the zonal travel cost model, which is discussed further below, can be described in the following six steps:

- divide the study area surrounding a particular recreational site into zones,
- survey a sampling of visitors to the site,
- determine visitation rates from each zone using the population survey sample,
- estimate travel costs based on survey responses and other data sources,

- specify and estimate, using regression analysis, the relationship between visitation rates and relevant explanatory variables (e.g. travel cost), and
- based on regression results, construct a site demand curve.

The first step in the zonal travel cost method is to divide the area surrounding the recreational site into zones in such a way the travel cost from each zone is about the same for all visitors. Zones may be estimated by drawing concentric circles around the site or by dividing the sample based on the county, city or district of origin.

The next step is to sample visitors to a site. This can be accomplished in several ways. Samples may be taken at the site, on travel routes to the site or in households of visitors in the relevant travel zones as determined above. Travel cost surveys have been implemented through on-site personal interviews, telephone interviews, direct mailings or some combination of techniques. Surveys are designed to collect data on travel costs, socioeconomic characteristics of the respondent, motives for the visit, and perceived environmental attributes of the site. The types of data collected for travel cost studies in primary surveys and from other sources include:

- number of visitors and their places of origin,
- number of visits per year, season or other relevant time period,
- socioeconomic attributes of visitors,
- length of time spent on the trip,
- amount of time spent at the site,
- direct travel expenses,
- the value of time for each respondent (opportunity cost of time),
- number of years respondent has been visiting the site,
- success of previous trips (e.g., number of fish caught, number of species of birds spotted),
- the total population in each zone of origin,
- other sites visited during the trip,
- other motives for the trip (e.g., visiting relatives, work-related travel),
- environmental quality attributes and/or visitors' perceptions of environmental quality at the site, and
- proxy measures for the price and quality of potential substitute sites for the study site.

The collected data are used to determine visitation rates for each zone from the sampled population, to estimate travel costs, and to evaluate the relationship between visitation rates and potentially relevant explanatory variables. Using information from the sampling of visitors, the number of annual (seasonal or other relevant time period) visits or visitor days per person in each zonal population is estimated. Travel costs are estimated based on the sum of the following:

- direct expenses incurred traveling to and from the site, including fuel, travel fares (e.g., air, rail, or bus) and other incidental costs,
- opportunity cost of time spent traveling to the site,[11] and

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[11]Valuing travel time is a problematic part of the calculation of travel costs. For a discussion of the importance of this issue for benefit estimation, the problems it raises, and how they might be resolved, see: Freeman (1993), Chapter 13, pp. 448-453.

- entry fees, guide fees, or other incidental costs incurred during the visit.

Upon determination of visitation rates and travel costs for various zones of origin, a relationship between these proxy measures for quantity demanded and price, as well as measures of other relevant explanatory variables, can be specified. For zones of origin (i = 1,2...n) this relationship might, for example, be specified as:

$$V_i = f\,(TC_i, INC_i, ENV, SUB_i)$$

where V_i represents the visitation rate to the site from zone of origin i, TC_i represents the cost of traveling to the site from zone of origin i, INC_i represents visitors' average income in zone i, ENV represents some measure of site environmental quality, and SUB_i represents some index reflecting the relative price and quality of potential substitute sites for visitors from zone of origin i. Given this specification, a basic linear regression equation can be estimated to produce parameter estimates for each variable.

The estimated equation is interpreted as the site demand function. Once estimated, the final step required to construct a demand curve is to "anchor" the data to actual visitation levels. This is accomplished by calculating the total number of visitors to the site given current travel costs and other explanatory variables. The total number of visitors from all zones is the first point, or anchor, of the demand curve. The remainder of the demand curve is constructed by simulating an entrance fee to the study site. The visitation rate-travel cost relationship is exploited by assuming that the total number of visits change in the same way for changes in entrance fees as they do for changes in travel cost. Based on this assumption, a demand curve can be constructed by calculating the number of visitors from each zone given different entrance fees. The value of recreational access to the site can then be estimated by calculating the area under the constructed demand curve.

To assess how site recreational benefits would change with a change in site quality, the parameter estimate for the quality variable could be used together with an estimate of the predicted change in that variable to derive a new demand function for the site, holding all other variables constant. The area between the old and new demand functions approximates the benefits associated with the site quality change.[12]

As indicated earlier, a number of important problems complicates welfare assessment for quality changes using the single-site travel cost model. One problem involves the need for quality measures that people perceive and act upon. Objective measures of site quality (e.g., dissolved oxygen or fecal coliform levels in a water body) are the most readily measured and predicted types of quality variables, but people may perceive site quality in ways that are at odds with these objective measures. There thus may be a need to link objective measures of site quality to quality variables such as angler success rates that more directly affect peoples' recreational choices.

[12]The use of the travel cost technique to evaluate changes in recreation quality in the water resource context, as well as a few applications, are discussed in Hansen, et al. (1991).

The bigger problem for incorporating quality measures into the single-site travel cost model is the need for variation in site quality data. Site quality measures based on peoples' perceptions and that span several recreational seasons can help to produce the variation necessary to estimate site quality parameters in the model. Even then, however, the estimated parameters for the quality variable would be useful for estimating the welfare effects of only marginal changes in site quality, while ecosystem restoration might often lead to nonmarginal improvements.

One approach that can be used to overcome this problem involves pooling observed visitation data for several different recreational sites of varying quality in the same region to estimate a regional travel cost equation. For example, for zones of origin (i = 1,2,...n) and regional sites (j = 1,2,...m), such an equation might be specified as:

$$V_{ij} = f\ (TC_{ij}, INC_i, ENV_j, SUB_{ij}).$$

An estimated equation based on this specification would provide the necessary variation in the site quality variables needed to estimate the welfare effects of change in recreational quality at the restoration site. However, this as well as other approaches to incorporate site quality in multi-site demand models involve simplifications which limit their ability to accurately characterize recreation demand (Freeman, 1993; pp. 462). For example, in the above equation the parameter estimates for site price and quality are constrained to be the same for all regional sites.

4.4 Strengths and Limits

The primary strength of the travel cost method for estimating recreational use benefits is that it relies on observed data reflecting the actual behavior of recreators. But this strength comes at the price of the specification and econometrics problems often encountered when trying to model the effects on recreator behavior of site quality and the prices and qualities of substitute sites. And, as discussed above, estimating the welfare effects of changes in site quality, which might often be the most important result of ecosystem restoration projects, requires simplifying assumptions to the model which may limit its ability to accurately characterize recreational demand.

The random utility model, with its attention to how people choose among quality-differentiated substitute sites, is better suited for assessing the benefits associated with changes in site quality, as well as that from the introduction of new sites. But the strength of the random utility model for assessing the recreational benefits of site quality changes and the introduction of new sites comes at the price of significantly greater data and analytical requirements. Moreover, by itself the model cannot explain the total number of recreational trips to a site. For this reason it is often necessary to supplement the model with an estimated continuous demand equation.

4.5 Resource Requirements

There can be a wide variation in the resources required to implement the various types of travel cost models. The money and time required are largely a function of the sophistication of the particular model used and related data needs and availability. The Corps routinely uses site intercept (traffic stop) surveys at existing Corps reservoirs to collect data on visitation rates and home addresses from site visitors. This data provides most of the raw data needed to implement travel cost models. So to the extent that a proposed restoration project under examination is located at an existing Corps facility, the costs and time associated with developing the necessary data might be minimal. For restoration project sites which are not coincident with existing Corps sites, however, primary data gathering would be needed. In this case, the use of site intercept surveys would likely be the most inexpensive survey option. Mail surveys would be another, relatively inexpensive survey alternative. Mail surveys cost about $10-20 per sample member, which includes mailing and distribution costs, data entry, and follow-up contacts. Regardless of the survey technique used, primary data gathering for a travel cost might take one or more years to complete because of the need to obtain data on the full extent of a recreational season and perhaps several seasons to account for differences in site quality over time.

The cost and technical expertise necessary to implement a travel cost study also depend on the degree of sophistication of the particular model used. At least a Master's level training in demand theory, statistical methods, and econometric techniques is required to conduct a single-site travel cost study. Moreover, experience in survey design and sampling procedures is also required for the implementation of travel cost studies which rely on primary data gathering. A study using the random utility model (or a regional travel cost model), requiring more sophisticated data sampling, management and econometrics, would generally require a Ph.D. level economist. The greater level of data requirements, modeling, and technical expertise associated with these models also translates into much higher implementation expense than that required for the single-site travel cost model.

The costs to implement a travel cost model in the ecosystem restoration context might be relatively modest if a single-site travel cost model was sufficient and data was gathered using a site intercept survey. However, in order to capture the effects of changes in site quality, the travel cost model might need to be applied using data on observed visits to a set of regional sites of varying environmental quality, or alternatively, involve application of the random utility model, which would involve much more data gathering and analytical expense. A range of expense for applying the travel cost model using data from two or more regional sites, or the random utility for all regional sites using data gathered in site intercept or mail surveys, might be $50-150 thousand.

4.6 References

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future. Washington, DC.
This text provides a thorough review and assessment of the current state of the art of resource valuation, both theory and methods. Travel cost models are discussed in Chapters 4 and 13.

Hansen, W.J. and D.D. Badger. 1991. *National Economic Development Procedures Manual--Recreation: Volume IV, Evaluating Changes in the Quality of the Recreation Experience*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 91-R-7.
This manual, which is part of a series of manuals designed to provide recreational evaluation procedures to implement the U.S. Water Resource Council's *Principles and Guidelines*, focuses on evaluation of qualitative differences in the recreational experience. It describes procedures and methods for valuing changes in recreational use values that result from management decisions impacting on recreational facilities nd services.

Hufschmidt, M.M., D.E. James, A.D. Meister, B.T. Bower, and J.A. Dixon. 1982. *Environment, Natural Systems, and Development: An Economic Valuation Guide*. The Johns Hopkins University Press. Baltimore, MD.
This text provides an introduction to economic methods for valuing environmental and natural resource systems. The travel cost method is described in Chapter 6.

Vincent, M.K., D.A. Moser, and W.J. Hansen. 1986. *National Economic Development Procedures Manual--Recreation: Volume I, Recreation Use and Benefit Estimation Techniques*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 86-R-4.
This report provides an expanded description of the recreation evaluation procedures recommended in the Water Resources Council's *Principles and Guidelines.* It summarizes the conceptual basis of procedures for recreation valuation, describes the mechanics of the travel cost method and other acceptable valuation techniques, and offers criteria for determining the applicability of various methods to particular planning studies.

5. HEDONIC PROPERTY VALUE METHOD

5.1 Introduction

Hedonic pricing models are used to infer the value of environmental attributes through the analysis of marketed goods whose market values depend in part on the level of these attributes. This class of valuation models is based on the assumption that, since consumers ultimately derive satisfaction from the characteristics of goods, the prices paid for certain marketed goods are directly related to the nature and supply of these characteristics. The specific hedonic technique considered in this chapter, the hedonic property value method, treats residential property as a composite good encompassing many separate component characteristics, including locational environmental attributes.[13] It relies on variations in residential property values to reveal implicit prices for these environmental attributes, holding all other relevant property and locational characteristics constant. These implicit prices can then be used directly to assess the value of marginal changes in environmental attributes, or to estimate attribute demand functions from which the welfare effects of nonmarginal changes in environmental attributes can be derived.

The first study to focus on the relationship between property values and locational environmental attributes centered on air quality. Ridker (1967) found that property values varied systematically with air quality levels when median housing characteristics were regressed against property housing characteristics, neighborhood characteristics, and amenity values including various measures of air pollution. He argued that the coefficient on the air pollution variable in the regression equation could be used to estimate the change in housing prices associated with changes in air pollution levels, and the sum of all price changes could be viewed as a measure of the benefit of improving air quality in an urban area.

The majority of hedonic property value studies conducted to measure environmental values have focused on air quality, although the technique has also been applied to value water resource related variables such as water quality and access, proximity to shoreline, and flood risk, among others.[14] In the ecosystem restoration context, the hedonic property value method may be useful for measuring the benefits to residential communities of changes in the quality or quantity of these types of water-related aesthetics, amenities, and ecological services. It might also be possible to apply the technique for estimating the value of ecosystem inputs that contribute to the production of marketed goods. For example, hedonics might be useful for estimating the effect on agricultural land values of changes in the quantity or quality of irrigation water resulting from ecosystem restoration.

[13]Other hedonic pricing models include hedonic wage studies which discern the value of environmental attributes, such as workplace safety, through examination of the labor market.

[14]For a review of hedonic property value studies applied to estimate the benefits provided by water resource attributes, see: Feather, et al. (1992).

5.2 Theoretical Basis for Technique

Like the travel cost method, the hedonic property value method is based on the assumption that the value of certain nonmarket environmental services are indirectly reflected in consumption of marketed goods that are complements for the nonmarket services. Unlike the former method, however, the hedonic technique analyzes the prices of the marketed good (rather than quantities consumed) to reveal the implicit prices of, and demands for, environmental attributes. The hedonic technique is thus built on the assumption that the value of the environmental attribute of interest is partially capitalized in property values. Two further assumptions are needed to implement the model: 1) the residential area used to model the relationship between property values and environmental attributes can be treated as a single market for housing services, and 2) this housing market is in equilibrium (i.e. home buyers have made utility-maximizing choices given housing prices for alternative locations, and these prices have brought buyers and sellers together to clear the market for the existing stock of homes in the market area.)

Application of the technique involves two stages of analysis. In the first, a hedonic price function (or implicit price function) relating property values to property and locational characteristics, including environmental attributes, is estimated. This produces estimates of the implicit prices for the environmental variables of interest. The second stage uses these implicit prices together with quantity data to derive an inverse demand function (willingness to pay curve) for differing levels of environmental attributes.

Specification of the first stage hedonic price function should account for all relevant variables that affect property values. These variables typically include vectors of *property* variables relating to the property lot and the house structural characteristics (e.g., lot size, number of bedrooms), *neighborhood* variables (e.g., level of crime, educational quality of schools, property taxes), *accessibility* variables (e.g., location to urban center, shopping centers, public transportation facilities), and *environmental quality* variables (e.g., proximity to open shoreline, flood risk). An hedonic price function including these variables can be stated mathematically as:

$$PV_{ij} = f\,(PROP_{ij}, NHOOD_{ij}, ACCESS_{ij}, ENV_{ij})$$

where:

PV_{ij}	=	property value at parcel i with environmental characteristics j
$PROP_{ij}$	=	is a set of property characteristics at parcel i with environmental characteristics j
$NHOOD_{ij}$	=	a set of neighborhood characteristics at parcel i with environmental characteristics j
$ACCESS_{ij}$	=	a set of accessibility characteristics for parcel i with environmental characteristics j, and
ENV_{ij}	=	the level of environmental characteristics j for parcel i.

A regression model specified and estimated with the above variables would yield a set of parameter estimates for the independent variables. Properties with superior environmental attributes would be expected to have higher property values, the effect of which is captured in the estimated regression coefficients for the environmental variables. These parameter estimates can be interpreted as the marginal value of environmental attributes, or the change in property value for a marginal change in environmental quality, holding all other property and locational characteristics constant. If the estimated hedonic property values function is linear, it will produce one estimate of the marginal implicit price of environmental attributes. Use of a nonlinear functional form for the hedonic price function, on the other hand, will yield marginal implicit prices which vary over alternative levels of the attribute.

Since the implicit prices for environmental attributes represent the marginal willingness to pay for these attributes, they can be exploited directly to estimate the welfare effects of marginal changes in environmental attributes. That is, the marginal value of a small change in a environmental attribute can be calculated simply by summing the implicit prices for each affected property owner. The implicit prices can also be used to derive the welfare effects of nonmarginal changes in environmental attributes if the environmental change will only affect a small number of properties relative to the size of the housing market (Palmquist, 1991).

Generally, however, estimating the welfare effects of nonmarginal changes in environmental attributes requires application of the second stage of the hedonic technique. While the marginal implicit price defines the household value for a small change in the environmental attribute, it does not directly reveal the individual household demand for the attribute (i.e. willingness to pay for varying levels of the environmental attribute). The second stage of the hedonic technique uses the estimated implicit prices for environmental attributes together with quantity data to estimate household willingness to pay functions (inverse demand functions) for environmental attributes. This is necessary since an individual household's willingness to pay for the environmental attributes is a function of the level of these attributes and the socioeconomic characteristics of the household (and perhaps the levels of other property and locational characteristics). These estimated household demand functions can then be exploited to estimate the welfare effects of nonmarginal changes in environmental attributes.

Household demand functions can be extremely difficult to identify, estimate, and interpret using the hedonic price data.[15] For this reason, many applications of the hedonic technique focus only on the first stage analysis and use the estimated implicit prices to calculate approximations of the welfare effects of nonmarginal changes in environmental attributes. Some of the important issues involved with estimating hedonic property value functions for use in this manner are discussed below.

5.3 Application of Technique

Hedonic property value studies that focus only on the first stage estimation and use of the hedonic price function to estimate the value of changes in environmental attributes are relatively straightforward to implement. They can be used to estimate the welfare effects of improvements in observable water resource related amenities, aesthetics, and certain ecological services that might be affected by ecosystem restoration as long as these environmental variables are perceived by property owners and capitalized in property values, and data on property values, environmental attributes and

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[15]For a comprehensive discussion of procedures and problems for second stage identification and estimation, see: Palmquist (1991) and Freeman (1993), Chapter 11.

other property and locational characteristics are available. In the water resources context, a number of recent studies have utilized an estimated hedonic property value function to directly estimate the benefits of water quality amenities (d'Arge and Shogren, 1989), lakefront amenities and aesthetics (Feather, et al., 1992), and flood control services (Thunberg and Shabman, 1990).

Hedonic studies of this type require the collection of large data sets on property values and characteristics. Ideally, data on property values should be drawn from an active market sample representative of the types of properties and the different attributes to be examined. The most preferred source of data is systematically collected information on the actual sales prices of individual homes, along with data on relevant property and locational characteristics (Freeman, 1993). These types of data are often collected by and available from multiple-listing services, property appraisers, and insurance agents. The majority of hedonic price modeling studies are done using cross sectional data, although time series data are often pooled with that data to add depth.

There is always some degree of uncertainty as to which independent variables to include when specifying the model. Planners may be faced with a difficult decision regarding how many variables, or which variables, to include in the model. The need to accurately model the determinants of property values would suggest including all potentially relevant explanatory variables. However, this can create problems of correlation between variables, or multicollinearity--a situation that may result in understating the significance of certain variables. For example, some of the likely variables examined in property value models (e.g. neighborhood variables) may be closely correlated to one another.

5.4 Strengths and Limits

Like the travel cost models, the main strength of the hedonic property value method is that it can be used to estimate use values associated with certain environmental attributes based on the actual choices of people. Moreover, property markets provide a good choice setting for estimating the benefits of relevant environmental attributes since they are relatively efficient in responding to information, and property records are typically very reliable.

There are also a number important limitations associated with property value modeling for estimating the welfare effects of changes in environmental attributes. First, the scope of environmental benefits that can be estimated using the technique is limited to the set of environmental services, such as locational amenities, that households can capture by buying or renting in a particular location. So if restoration projects do not impact areas where residential parcels are concentrated, there would be insufficient data to evaluate the effects of restoration on the amenity in question. Second, property value models only capture the willingness to pay of residents for perceived differences in environmental attributes and their direct consequences. So, for example, if people are not aware of the linkages between property location and flood risks, the value of properties with low flood risks will not be capitalized into property prices.

5.5 Resource Requirements

Implementation and interpretation of an hedonic study can be relatively complex and require considerable statistical and econometrics expertise, particularly if the second stage analysis is needed. A firm grounding in demand theory is also needed since the results of a hedonic pricing study depend heavily on specification of the model--particularly the need to carefully conceptualize and empiricize the environmental variable, and the choice of functional form and estimation techniques. Finally, because the technique relies on the collection, synthesis and manipulation of large amounts of data, a skilled data manager is generally needed.

The time and expense of conducting a property value study depends crucially on the availability and accessibility of the necessary data. The availability of computerized data bases on property prices, characteristics and neighborhood variables is a must for keeping costs down. If data in this form are readily available, the main expense and labor time will involve cleaning the data. But if the data on these variables were not readily accessible in this form, then the researcher would need to go into public records on individual recordation deeds and assessment records to get the necessary data, which could greatly increase study time and cost. The same is true for data on the environmental variable of interest. If readily available and accessible, study time and cost can be kept down. If, on the hand, getting data on the environmental variable requires aerial photography, analysis of maps, site visits and measurements or the like, study time and cost will rise.

A first stage hedonic application to measure the benefits of proximity to shoreline, for example, where all the needed data are readily available and computer accessible, might take 4-6 months to complete at a cost of $30-50 thousand. If the data on property and environmental variables were not readily available and computer accessible, however, study time and cost could rise several fold.

5.6 References

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6. CONTINGENT VALUATION METHOD

6.1 Introduction

The contingent valuation method (CV) relies on the use of sophisticated surveys to obtain information from respondents about their preferences for environmental goods and services. In a CV survey, respondents are presented with a hypothetical scenario describing a potential improvement in an environmental service and asked about their willingness to pay to obtain the improvement. Results obtained from a random sampling of a target population can be used to make inferences about the value that the target population places on the service.

The flexibility of the CV method permits its application to a wide range of nonmarket valuation problems. Past CV applications have focused on resource problems ranging from prevention of the extinction of the striped shiner to recreational benefits of water quality improvements. A recent CV bibliography lists over 1,000 CV studies that have been conducted, most in the last decade (Carson et al., 1994) .

The CV method could be used to measure the use values associated with any one or all of the environmental service flows that might be augmented through ecosystem restoration, as long as the nature and extent of these improvements could be clearly characterized for (and understood by) survey respondents. And the CV method is the only valuation technique capable of estimating nonuse (existence) values, and can be used in a "Total Valuation Framework" that considers all component use and nonuse benefits resulting from ecosystem restoration (Randall, 1991) .

Conjoint analysis is a related method which includes a variety of multi-attribute, expressed preference techniques (e.g. contingent ranking, contingent pairwise rating, contingent choice) based on the principle that goods and services are composed of various attributes. In a conjoint analysis survey, respondents are presented with two or more alternative scenarios (e.g., bundles of attributes representing different levels of environmental commodities and associated costs to achieve these levels) and asked to rank, rate, or choose among the alternatives based on their preferences for the attributes in each scenario. By including price as one attribute, respondents' rankings or rating of attributes or choices of attribute sets can be used to derive values for nonmarket attributes by exploiting revealed information about the marginal rate of substitution between the nonmarket attribute and price. In recent years, researchers have begun to experiment with this approach as an alternative to contingent valuation and other methods for valuing nonmarketed environmental commodities (see, for example: Opaluch, et al., 1993). While the technique shows promise for estimating environmental benefits, this chapter focuses on the CV method since it represents the most direct and commonly used expressed preference approach.

6.2 Theoretical Basis for Technique

The theoretical assumption underlying the CV technique is that people have well-defined and stable preferences for environmental services which can be elicited through carefully designed and administered surveys. The ways in which environmental benefit estimates can be derived from survey results depends on the specific form of survey questions and responses. CV survey questions may be presented in a variety of different formats, including:

- direct, open-ended questions (e.g. What is the maximum amount you would be willing to pay for the environmental change?) and variations (e.g. the payment card method) which provide respondents with several different WTP amounts from which a maximum can be chosen,

- bidding game questions, in which individuals are first asked whether they would be willing to pay a certain price, and if the answer is yes, the question is repeated at successively higher prices until the individual answers no, and

- discrete choice (take it or leave it) questions, including contingent purchase (buy or not buy at a given price), contingent voluntary contribution (make or not make a contribution of a specific amount), and contingent policy referendum (vote yes or no for a policy at a stated policy cost).

The first two forms elicit continuous data on direct expressions of willingness to pay (WTP) for specific environmental changes. In the ecosystem restoration context, these formats could be used to elicit values for environmental improvements which could be interpreted as direct measures of the welfare change associated with environmental improvements.

These direct valuation questions produce a maximum WTP estimate for each survey respondent in the survey sample. One way to derive an aggregate measure of welfare change for the entire population from which the survey sample is drawn is to calculate the sample mean of the WTP estimates, and multiply it by the total population. Another way would involve estimating a value function by regressing the WTP responses against income and other socioeconomic characteristics of the respondents. The resulting parameter estimates could then be combined with data on the socioeconomic characteristics of representative groups within the population to produce an aggregate measure of welfare change (Freeman, 1993).

With the discrete choice format, which produces yes or no response data for different WTP amounts rather than direct expressions of individual WTP, it is necessary to exploit discrete choice models to derive individual welfare measures associated with environmental changes. These models can be used to estimate indirect utility functions from which WTP estimates can be derived (or to indirectly estimate willingness to pay functions for survey respondents) using survey responses and data on the socioeconomic characteristics of respondents. Thus, unlike the CV forms that elicit continuous data on maximum willingness to pay, deriving benefits estimates from discrete choice CV responses requires the use of fairly sophisticated modeling and econometrics.

6.3 Application of Technique

The application and use of the contingent valuation method for measuring the benefits associated with ecosystem restoration would involve the following study components:

1. Choice and development of the CV survey format,
2. Survey instrument design, pre-testing, and pilot study,

3. Survey administration (sampling and field administration), and
4. Econometric analysis and benefits estimation.

As discussed in the previous section, there are a variety of different CV formats that could be used to implement a CV study, including open-ended WTP questions, payment cards which ask respondents to choose among a set of different WTP amounts, iterative bidding games, and various discrete choice formats. In addition to their different analytical and econometric requirements for deriving benefit estimates, the different CV forms are associated with different performance characteristics and incentive properties.

Discrete choice CV surveys, particularly the policy referendum format, have become the preferred approach because of a number of advantages with regards to performance and incentives properties that they have relative to other survey approaches (Freeman, 1993). First, discrete choice questions pose a relatively simple decision choice for respondents, since only a yes or no response is required. Second, the take-it-or-leave-it context is a familiar choice context in the marketplace, and if the payment vehicle is a tax, a policy referendum format simulates actual political referendums which are also a familiar choice context for people. Third, if respondents believe that resource allocation decisions based on survey results will follow a plurality voting rule, then the policy referendum format is believed to be "incentive compatible". That is, with properly framed policy referendum questions, there should be no incentive (opportunity) for people to strategically base their responses in a way they think might influence the survey results in a way that serves their personal interests.

Once a CV format has been chosen, the next steps in a CV study involve the design, testing, and administration of the survey instrument. Since the CV method relies on responses to hypothetical questions, a variety of potential errors can be introduced and result in misleading results if surveys are not carefully designed, tested, and administered. The ways in which questions are framed, the mode of survey administration, the described payment format, and interaction with interviewers can all affect results. Mitchell and Carson (1989; Chapter 11) classify these potential sources of error as 1) incentives to misrepresent WTP amounts, 2) implied value cues, and 3) scenario misspecification.

Potential problems relating to incentives to misrepresent WTP include the potential for respondents to provide a response with the intention of influencing the results of the survey in a way that serves their personal interest (i.e. strategic responses), and the potential for respondents to provide an affirmative response due to a tendency to answer questions in the affirmative rather than the negative (i.e. yea-saying). Implied value cues refers to the potential for elements of a valuation scenario to be interpreted by respondents to imply information about the value of the commodity of interest. These are often related to the form of the survey questions. One example is the potential for respondents to base their response on the starting point in a bidding game (i.e. starting point bias). Scenario misspecification errors can occur when respondents are presented with a scenario that is described incompletely or inadequately communicated and the respondent interprets the scenario differently than the researcher intended. One example is the potential for respondents to consider a more comprehensive environmental good than the one specified in the description provided in the survey (i.e. embedding).

Identifying and controlling for these types of potential survey design effects has been the focus of methodological and empirical research in recent years. Thorough reviews of these potential sources of error and ways to avoid or alleviate them through careful survey design, testing and administration can be found in Mitchell and Carson (1989). Survey design and implementation in this context is discussed below.

A CV instrument must include the following elements:

- The choice scenario, which includes a description of the good or service and how it is to be provided, as well as an explanation of the means by which payment would be provided (i.e. payment vehicle);

- The preference elicitation questions, which asks respondents about their willingness to pay for the good described (or whether they would buy or not buy a good at a stated price; vote yes or no for a policy at a given policy cost), and

- Validation questions, to verify comprehension and acceptance of the scenario and to elicit socioeconomic and attitudinal characteristics in order to interpret variation in responses to the valuation question across respondents.

Two primary components of the market scenario are the definition of the good or service to be valued and the payment vehicle. To obtain meaningful value estimates, it is imperative to define the good or service at issue in a way that is meaningful and understandable to respondents. While verbal descriptions are standard, visual aids such as photographs, charts, maps, and videos are increasingly used to provide more thorough and understandable definitions. Focus groups and pretests of the survey instrument enable the researcher to experiment with different visual aids to determine which are most effective (The ability to use visual aids depends on the type of survey administered). One very important factor that needs to be communicated to respondents is the available regional substitutes (and complements) for the environmental services for which values are elicited.

Focus groups are useful for: identifying an appropriate means of conveying the relevant attributes of the described scenario; determining an appropriate payment vehicle; testing potential elicitation methods; pretesting the preliminary survey instrument, and; identifying and controlling for potential sources of error. Through the development and pretesting of the survey instrument, resource attribute descriptions and individual preference elicitation questions can be refined for incorporation into the final questionnaire.

The payment vehicle is the specific mechanism for payment defined in the survey instrument and expressed in the WTP question. For example, if fishing opportunities are being valued, an appropriate payment vehicle may be an increase in fishing license fees or an increase in fishing expenses. When considering an appropriate payment vehicle, it is important to identify a vehicle that is both realistic and neutral. Where appropriate, the actual means of payment should be used to add realism to the scenario. While promoting realism, it is important to consider neutrality as well. For example, use of higher taxes may be inappropriate if respondents express a general dissatisfaction with tax increases. The appropriateness of potential payment vehicles can also be evaluated in focus groups and pretests.

Supplemental data gathered in the survey instrument may include validation questions, questions about socioeconomic characteristics of the respondent, and questions designed to identify “environmental attitudes” and knowledge of environmental issues. Socioeconomic characteristics may be used as explanatory variables in regression analysis. Validation, attitude, and prior knowledge questions help to identify motivations for survey responses, and to identify and eliminate protest bids.

A CV survey can be administered through in-person interviews, telephone interviews, or through mail surveys. In general, personal interviews are considered to be the most effective administration approach, but are also typically the most expensive. Telephone and mail surveys can be much less expensive to administer but responses tend to be less complete and less reliable, with lower response rates. Nevertheless, these approaches generally enable researchers to elicit more total responses at substantially lower cost.

An example CV study in the water resource context is provided by Loomis, et al. (1991), which focused on estimating the benefits associated with improving an ecosystem containing 85 thousand acres of freshwater wetlands in the California San Joaquin Valley. The study used a “total valuation framework” to estimate all wildlife-related wetland values, which the authors contend include on-site recreational benefits, commercial values, and existence values. A discrete choice policy referendum format was used to ask respondents a series of questions about their willingness to pay specific increases in annual taxes for various management scenarios. One management scenario involved use of water management to ensure the maintenance of existing wetland acreage. The other management scenario involved purchasing additional acres and water supplies in order to increase the total wetland area to 125 thousand acres. Survey respondents were told that if no additional management actions were undertaken, wetlands in the Valley would be reduced to 27 thousand acres, with a corresponding decrease in wildlife populations.

The study data was collected using telephone interviews of respondents who had earlier been mailed a survey booklet which they had in front of them during the interview process. A random sampling of 1573 total households in the Valley and other parts of the state were first contacted by phone to solicit their participation in the study, and of these, 991 were scheduled for interview. Ultimately, a total of 803 households completed the telephone interview after receiving the survey booklet (a total response rate of 51 percent). For the maintenance scenario, the study estimated mean annual household benefits as $174 for Valley households, and $152 for other California households. For the improvement scenario, the study estimated mean annual household benefits as $286 for Valley households, and $251 for other California households. These estimates were used to produce aggregate benefit estimates for all California residents of over $1.5 billion for the maintenance scenario, and $2.5 billion for the improvement scenario.

6.4 Strengths and Limits

The CV method (and other expressed preferences valuation approaches) carry a number of important advantages over the revealed preferences approaches. Foremost is the flexibility of the technique which facilitates its use to elicit use benefits associated with the improvement of virtually any ecosystem service, as well as nonuse benefits--something that is outside the scope of the behavioral models. Moreover, the technique can be used in a "total valuation framework" that considers all ecosystem component benefits, including nonuse values, either sequentially or simultaneously. In order to produce an aggregate estimate of ecosystem use values using the revealed preference approaches, several different techniques might need to be applied to estimate use values associated with individual resource service flows. In addition to the difficulty and expense of this procedure, the aggregation of separate use values calculated in this manner could introduce systematic error in total benefit estimates because independent valuation does not fully account for the substitutability and complementarity among individual resource services. Use of the CV method within a total valuation framework avoids this problem by estimating total resource benefits while considering the interactions between individual resource service flows (Randall, 1991).

These advantages of the CV method must be weighed against several very important potential problems. One problem is that it may often be difficult to identify the relevant population over which to aggregate individual benefit estimates calculated using the CV method. While the revealed preference approaches define the extent of the market for ecosystem services as that associated with the complementary marketed good examined, the CV approach offers no guide as to the extent of the market for ecosystem services. This is particularly troublesome when using the CV method to estimate nonuse values for pure public goods. The nature and extent of the population who might hold existence values for a particular ecosystem often will not be readily apparent.

Another problem involves controlling for the survey design errors discussed earlier. State-of-the-art applications of the CV method have become increasingly expensive as more and more procedures have been employed in an effort to reduce, test for, and control the variety of potential sources of error in survey design.

Most importantly, the CV method, unlike the revealed preference approaches, is not based on actual behavior, but instead relies on answers to hypothetical questions to elicit preferences for environmental resources. Thus, no matter how sophisticated the survey design and sampling methods used, the possibility remains that survey respondents may provide something quite different than their actual preferences for the specific environmental good for which values are being estimated. For example, survey responses may instead be motivated by the "warm glow" of giving, which may bear little resemblance to what they actually would pay for the resource in question in an actual economic or political choice setting. This ever-present potential for "hypothetical bias" is something that cannot be completely controlled through careful survey design, testing, and administration.

This criticism of the CV method has been voiced by many economists as well as psychologists involved in behavioral decision research. Some in the latter group have argued with the economic assumption underlying the CV method: that people have well-defined and stable preferences for environmental goods, and that these preferences can be recovered through CV surveys. Instead, some behavioral psychologists have voiced the view that when people are faced with choices made under complex and unfamiliar conditions and with limited information, the choices observed are not retrieved from previously formed preferences, but are more likely constructed based on the choice context (Schkade, 1994).

6.5 Resource Requirements

There can be a wide variation in resource requirements for a CV study application in the ecosystem restoration context, driven primarily by the degree of study sophistication with respect to the form of the CV survey used and the design, testing, and administration of the survey instrument. For example, use of an open-ended CV question format would generally be much less expensive and time consuming to design, implement, and use for estimating restoration benefits than a double-bounded, discrete choice policy referendum format which requires much more extensive econometric modeling and other analysis for benefits estimation. Moreover, state-of-the-art CV studies increasingly employ sophisticated methods to reduce, test for, and control potential sources of error in survey responses, which have greatly increased study times and cost. For example, the quality of a CV survey depends as much on the amount of information that is known *a priori* about the way people think about the resource in question as the information obtained through survey implementation. Information on who uses or values the resource, how it is used or valued, and who knows about the resource's existence is often important for developing the survey instrument and determining sampling procedures. This information often can only be obtained through focus groups conducted prior to survey development, which will raise the costs and time required to implement a CV study.

In addition, a major determinant of study time and cost involves the specific survey administration technique employed. Mail surveys and telephone interviews are generally the least expensive survey options. Costs for mail surveys can range from $10-20 per sample member, which includes expenses for printing, mailing and distribution, and follow-up post card or telephone reminders needed to reach response rates of 40-60%. Telephone surveys generally cost $20-30 each for a 15-25 minute interview, and normally involve less survey time than mail surveys. Finally, in-person interviews, which are generally viewed as the most reliable survey technique, are the most costly and time-consuming survey method. In-person interviews can cost $100 per interview or considerably more if they are hard to arrange and fully complete. Regardless of the survey administration technique used, survey costs and time will rise with the level of sampling.

A final consideration for resource requirements is technical expertise. Experience in survey design and testing and sampling procedures is critical. Moreover, while a researcher with a Master's level training in statistical methods and econometric techniques might be enough to conduct a CV study using the more elementary formats, a Ph.D. level training in statistical methods and econometric techniques would normally be required to implement a discrete choice CV study.

Costs and time for a CV study conducted for an ecosystem restoration project are difficult to predict due to the many factors that can influence these variables. Generally, a CV study in this context might require a modest level of sampling (e.g. 200-400 sample members), and could probably be conducted using a mail survey or telephone interviews to reach a reasonable 50% response rate (100-200 completed surveys). Such a CV study, employing a discrete choice format and limited pre-testing of the survey instrument might cost $50-$100 thousand and involve 6-12 months study time.

Changing some of these variables could substantially increase study time and cost, however. For example, extensive pre-testing and pilot study of the survey instrument, a much greater level of sampling, or the use of in-person interviews would all be expected to increase study cost and time significantly.

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This text may be considered the CV "how to" manual, providing a systematic review of the contingent valuation method and its application. The theoretical basis of the methodology is identified, measurement biases, sampling and aggregation issues are addressed, and suggestions made for future research.

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This article argues that use of the contingent valuation method for estimating the benefits of the Corps' ecosystem restoration efforts is of questionable value because a true parameter value that represents the public's monetary value for restoring environmental resources probably does not exist in any practical sense.

7. BENEFITS TRANSFER

7.1 Introduction

Application of the valuation techniques discussed in the previous chapters for the estimation of ecosystem restoration benefits could often be data and resource intensive, and involve substantial study time. When data, time, or resource limitations and constraints limit the primary application of these techniques for the evaluation of some ecosystem service at a restoration project site, it might be useful to instead use unit values or valuation models developed for the same service at another site. Such "benefit transfers" provide a way to relatively quickly and inexpensively develop benefit estimates for certain types of services that might be augmented through ecosystem restoration.

Benefits transfer refers to the process of using the valuation results for some site derived in a previous study (the study site) to develop benefit estimates at the site for which an ecosystem restoration project is being investigated (the project site). There are two types of benefits transfer: 1) unit value transfers, and 2) valuation model transfers. The first type involves using average values for some unit of a resource service (e.g. average value per recreational activity day) developed for the study site, coupled with estimated units of the service provided by the project site, to produce benefit estimates for the project site. The second type involves transferring estimated demand or value (willingness to pay) functions[16] derived for a study site to produce benefit estimates for the project site. This is accomplished by combining the estimated coefficients for the explanatory variables in the demand or value functions developed for the study site together with data for these variables gathered for the project site.

The use of benefits transfer was pioneered by the Corps to estimate the recreational benefits of proposed water development projects. As early as 1962 the Corps began to use administratively-approved unit day values, which were developed using expert judgement, as an approximation of average willingness to pay for recreational activities at Corps reservoirs. In later years the Corps began transferring entire recreation demand functions developed for existing reservoirs using the travel cost model to estimate the recreational benefits associated with proposed new reservoirs. In recent years the Corps has developed regional (multi-site) demand models for recreation that incorporate variations in site quality and facilities. These regional models are used to adjust the definition of the choice alternatives based on the problems being studied, which further facilitates benefits transfers for recreational services (Loomis, 1992).

As in the water resource development context, benefit transfers could potentially play an important role for estimating recreational benefits associated with ecosystem restoration projects. In this context they might be useful for valuing new recreational sites as well as for valuing improvements in the quality of existing sites. Although past applications of the technique in the

[16] A demand function, such as that produced by the travel cost model, provides the estimated relationship between total value (use and benefit) and the determinants of demand. A value function, such as that produced by the contingent valuation methods, shows the estimated relationship between household willingness to pay (benefit) and value determinants. The difference between the two involves the use (market) component of total value.

ecosystem context have focused on recreational services, the technique might also be useful for valuing other types of ecosystem services that contribute to direct use benefits in production or consumption. The remainder of this chapter discusses the potential use of benefits transfer for estimating recreational benefits, but the issues raised apply equally to use of the technique for valuing other types of ecosystem restoration benefits.

Transferring previously estimated ecosystem values such as recreational benefits from a study site to an ecosystem restoration project site is problematic because such values are highly sensitive to various site-specific variables. Thus, benefits transfer may be appropriate only under certain restrictive conditions which can limit the applicability and potential usefulness of the technique in the ecosystem restoration context. As will be discussed further below, use of the benefits transfer procedure for estimating recreational benefits at project sites may be appropriate when:

- the study site is similar to the project site,
- the activity under investigation at the project site is similar to the activity evaluated at the study site, and
- the original valuation study was accomplished using sound research practices and the results were viewed as valid and reliable.

7.2 Theoretical Basis for Technique

Benefits transfer is based on the idea that it might sometimes be reasonable to transfer valuation results developed for one site to another site under certain conditions. Whether or not such a transfer is reasonable for a particular application depends primarily on the degree of similarity in a number of important variables for the two sites. Recreation demand (value) functions and unit value estimates are calculated in primary studies for sets of actual users of recreational goods at particular sites. They are therefore based on a myriad of site-specific factors, including:

- the specific site recreational service flows,
- site quality factors (e.g. water quality, type of game fish available),
- regional factors (e.g. distance from user populations, number of close substitutes in the region), and
- market factors (number of users and their socioeconomic characteristics).

Because estimated demand (value) functions and unit value estimates produced at study sites are site/region/user specific, their cross-application to estimate recreational use values at project sites will be deficient unless the two sites share the characteristics listed above. These factors can be used to develop a set of criteria for determining when use of the benefits transfer procedure may be reasonable.

Following Boyle and Bergstrom (1992), a particular *unit value* transfer might be deemed reasonable when the following criteria are satisfied:

- the nonmarket commodity valued at the study site is similar to the nonmarket commodity to be valued at the project site,
- the study and project sites are similar,

- the populations affected by the nonmarket commodity at the study site and the project site share similar characteristics, and
- the primary valuation study was based on adequate data, and sound economic methods and empirical techniques.

Desvousges, et al., (1992) list a similar set of criteria for selecting among study sites for transferring a *valuation model* to estimate the welfare impacts at a project site resulting from water quality changes. These selection criteria include:

- the primary valuation study was based on adequate data, sound economic methods and correct empirical techniques,
- the change in site attributes (service quality) valued at the study site should be similar to the expected change at the project site (to avoid extrapolating from study sites with large changes in site attributes to project sites that involve only small changes, for example),
- the valuation model described willingness to pay (or demand) as a function of socioeconomic characteristics,
- the study and project sites are similar, or the study site valuation model contains regression results that describe willingness to pay (or demand) as a function of site characteristics, and
- short of usable information on own and substitute implicit prices for the study site, the markets for the study site and project sites should be similar.

Benefits transfer relies on the assumption that the empirical results of a primary study may be applicable in valuing a similar site or system. As such, benefits transfer relies on the validity of the theoretical construct of the underlying model used to estimate values in the original study. Another factor that should not be overlooked when selecting among primary valuation studies for a benefits transfer is the set of researcher judgements that were used to implement the primary study (McConnell, 1992). By transferring a model or value estimates derived from one valuation context to another context, one is implicitly transferring all of the judgments the researcher made in the original study to the new study. These judgments tend to increase the site-specific nature of original benefit estimates, and the judgments made while conducting original benefit estimation studies may not be appropriate for the project site.

7.3 Application of Technique

There are several steps involved in a benefits transfer application. First, it is important to specify the specific recreational services and values to be estimated at the project site. This might involve, for example, the total value of a set of specific recreational activities at a site or the change in value related to a change in some site quality attribute. The attributes of the site and characteristics of site users should be identified in this stage so that the planner can determine the appropriateness of potential study sites for unit value transfer, or for which project site data would be required to implement a valuation model transfer. Attributes may include, for example, environmental quality at the site, recreational activities, and degree of crowding. Characteristics of the users may include socioeconomic characteristics such as age, sex, education level, and experience with activities at the site.

Identification and evaluation of potential study sites is the next stage in the transfer process. At this time, the planner should conduct a thorough review of the literature, both published and unpublished, to identify studies that may be similar in nature to the evaluation required at the policy site. It is important to consider both the relevance of the potential study site as well as the quality of the values obtained in the original study. It may therefore be preferential to use more recent studies that employ state-of-the-art data collection and value estimation procedures (Boyle and Bergstrom, 1992).[17] Contacting researchers who conducted studies on the potential study sites may be useful to identify details of the study site application such as judgments made by researchers that are not reported in published literature. The selection criteria outlined in the previous section could then be used to make a final choice among the candidate valuation studies.

The final step in the benefits transfer process is the actual transfer of the study results to the project site. To estimate monetary benefits of recreational activities using *unit values*, three types of information are needed:

1) the value of each recreational activity per unit of time (e.g. average value per day),
2) an estimate of the level of usage for each activity, and
3) the extent of the geographic market (i.e. number of users) for each recreational activity.

An example of unit value transfer is provided by Luken et al. (1992). This study estimated the benefits of proposed regulations on the pulp and paper industry using various estimates of water-based recreation which were transferred from contingent valuation and travel cost studies of river water quality and recreational benefits.

A *valuation model* transfer involves a similar, but generally more involved, set of steps. To implement this type of more sophisticated benefits transfer, a planner must:

1) gather the relevant data for the project site on household characteristics in the market area and other relevant variables that are included as explanatory variables in the valuation model to be used,
2) insert this data into the transferred demand (value) function derived in for the study site, and,
3) in the case of a value function transfer, develop estimates of the number and nature of users for the recreational services of interest at the project site.

A number of studies designed to test the reliability of valuation model transfers in the recreation context illustrate the basic procedures. These include a study by Desvousges et al. (1992) which uses a value function transfer based on the contingent valuation method, and Loomis (1992) which uses a demand function transfer based on the single-site travel cost model.

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[17]Unit value estimates for a variety of recreational activities, which are based on expert judgement, are included in the *Principles and Guidelines* (Water Resources Council, 1983). Unit value estimates for recreational activities based on systematic reviews of willingness to pay valuation studies have been developed for the U.S. Forest Service as part of its Resource Planning Program (Walsh, et al., 1992).

7.4 Strengths and Limits

The main advantages of the benefits transfer procedure relate to its ability to reduce study cost and time. The approach may be particularly appealing when funding limitations or time constraints preclude an original valuation study. But there are several important factors that restrict the ability to produce defensible benefit estimates using the procedure, as illustrated by its potential application for estimating recreational benefits. First, when using the procedure it is difficult to account for regional factors (such as the range and quality of substitute recreational sites) as well as site characteristics (e.g. amount of congestion in a given recreational area) that affect individual's valuation of and demand for recreational sites. In addition, it might often be difficult to determine the size of the population affected by a change in the quantity or quality of recreational services at project sites. These difficulties are particularly problematic for unit value transfers, since the available average unit values are necessarily tied closely to regional, site, and user characteristics at study sites that may not correspond very well to those associated with the project site. Moreover, all types of benefits transfers face the problem of finding original studies which examined the same types of changes to recreational services that are under examination for project sites. For example, while ecosystem restoration may often alter the quality of recreational services at project sites, most of the existing literature on recreational services reports values associated with changes in service quantity, not quality (Krupnick, 1993).

7.5 Resource Requirements

Benefits transfer is a low cost alternative to original valuation studies that can be conducted in a relatively short period of time. Relative to the valuation techniques presented in this report, it is generally much less expensive and time consuming. A benefits transfer study might cost $10-20 thousand to implement, and be completed in 1-2 months, depending on whether unit value estimates or valuation model transfers are used, and the availability of secondary data on the number and characteristics of recreational users of the project site.

Implementing a benefits transfer generally requires expertise in demand theory, nonmarket valuation techniques, and statistical and econometrics methods. Although the level of expertise needed is perhaps not as great as that required to implement original studies of ecosystem restoration benefits, a firm grounding in these areas is necessary for evaluating original valuation studies for applicability, validity, and reliability.

7.6 References

Bergstrom, J. C. and H. K. Cordell. 1990. "An Analysis of the Demand for and Value of Outdoor Recreation in the United States." *Journal of Leisure Research* 23(1): 67-86.
Demand equations for 37 outdoor recreational activities were estimated using a multi-community, multi-site travel cost model. This model represents an alternative approach for estimating standard values for outdoor recreation over multiple populations and sites.

Boyle, K.J. and J.C. Bergstrom. 1992. "Benefit Transfer Studies: Myths, Pragmatism, and Idealism." *Water Resources Research* 28(3): 657-663.
In this paper, the authors propose a systematic, conceptual foundation for conducting benefit transfer studies, and suggest a research agenda to identify conditions under which valid benefit transfer estimates can be derived. They conclude that the

research agenda must be accompanied by improved conduct and reporting of original valuation studies before benefit transfer can become a widely used tool in public policy analyses.

Desvousges, W.H., M.C. Naughton, and G.R. Parsons. 1992. "Benefit Transfer: Conceptual Problems in Estimating Water Quality Benefits Using Existing Studies." *Water Resources Research* 28(3): 675-683.
The problems encountered in using existing studies to measure the benefits of water quality improvements are investigated in this paper. The authors propose criteria for selecting transfer studies and present a case study of a valuation model transfer. They conclude that existing studies were not designed for transfer, thus placing limitations on the current effectiveness of transfer, and suggest future research to address these limitations.

Krupnick, A.J. 1993. "Benefit Transfers and Valuation of Environmental Improvements". *Resources*. No. 110 (Winter).
This article discusses the growing demand for analyses of the benefits of environmental improvements and the interest this has generated for the use of benefit transfers. It discusses the different contexts in which benefit transfers have been used to date, other possible applications, and the problems that must be overcome for appropriate use of the procedure for valuing environmental changes in different contexts.

Loomis, J.B. 1992. "The Evolution of a More Rigorous Approach to Benefit Transfer: Benefit Function Transfer." *Water Resources Research* 28(3): 701-705.
The assumptions underlying the transfer of benefit estimates from recreation sites in one state to another state for the same recreation activity are empirically tested. The equality of demand coefficients for ocean sport salmon fishing in Oregon versus Washington and for freshwater steelhead fishing in Oregon versus Idaho is rejected.

Luken, R.A., F. R. Johnson, and V. Kibler. 1992. "Benefits and Costs of Pulp and Paper Effluent Controls Under the Clean Water Act." *Water Resources Research* 28(3): 665-674.
This paper quantifies local improvements in environmental quality from controlling effluents in the pulp and paper industry using unit value benefits transfer.

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In this paper, it is argued that standard hypothesis testing in model estimation is less important than the researcher's judgment about how the model ought to work. The author suggests that there are several major research issues which may influence final benefit estimates that are determined by the researcher. Therefore, he concludes, original benefit estimates which were tailored for a specific application cannot be treated as is they came from a strictly random process.

Walsh, R.G., D.M. Johnson, and J.R. McKean. 1992. "Benefit Transfer of Outdoor Recreation Demand Studies, 1968-1988." *Water Resources Research* 28(3): 707-713.
This paper illustrates how the results of previous studies could be adjusted to develop some tentative estimates of nonmarket values for future policy analysis. The authors analyze estimates of economic values per recreation day for 19 different recreational activities based on a meta-analysis of 120 recreational demand studies conducted from 1968 to 1988. The authors note that the evaluation of some potentially important variables should help improve statistical analysis and the allocation of resources to new studies, while identifying the need to examine additional variables that might conceivably be more important that those considered in the past.

Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington, DC.
This manual establishes the appropriate concepts, procedures, and techniques for analytical studies conducted by the Corps to evaluate the National Economic Development benefits of civil works plans.

8. LIST OF KEY REFERENCES

General

Braden, J.B. and C.D. Kolstad (eds). 1991. *Measuring the Demand for Environmental Quality*. North Holland. Amsterdam.

This book provides a comprehensive review of the state-of-the-art in the theory and measurement of the demand for environmental goods and services, including assessments of the relative strengths of the various available methods for evaluating preferences for important classes of environmental goods and services. It is intended to be a reference for graduate students and practitioners in the field.

Cole, R.A., J.B Loomis, T.D. Feather, and D.F. Capan. 1996. *Linkages Between Environmental Outputs and Human Services*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 96-R-6..

This report, which was prepared as part of the Corps "Evaluation of Environmental Investments Research Program", identifies links between the various ecological effects of ecosystem restoration projects and their socioeconomic impacts which give rise to social value.

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values: Theory and Methods*. Resources for the Future. Washington, DC.

This text provides a comprehensive review and assessment of the state-of-the art in the theory and measurement of environmental and natural resource values. The material is geared toward economics graduate students and practitioners in the field.

Johnson, N.B., W.J. Hansen, J. Warren, F.R. Reynolds Jr., C.O. Foley, and R.L. Fulton. 1988. *National Economic Development Procedures Manual--Urban Flood Damage*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 88-R-2.

This report provides an expanded description of the urban benefit evaluation procedures recommended by the Water Resource Council's *Principles and Guidelines*. The report present specific procedures for the entire process of urban benefit estimation and is intended for use in project feasibility planning and evaluation.

Mills, A.S., S.A. Davis, and W.J. Hansen. 1991. *National Economic Development Procedures Manual--Urban Flood Damage, Volume II*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 91-R-10.

This is the second in a series of manuals designed to provide procedures and techniques to measure flood damage and to further implement the U.S. Water Resource Council's *Principles and Guidelines*. This manual is a primer for conducting comprehensive flood damage and related surveys.

Robinson, R., W. Hansen, K. Orth, and S. Franco. 1995. *Evaluation of Environmental Investments Procedures Manual, Interim: Cost Effectiveness and Incremental Cost Analyses*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 95-R-1.

This manual, which was prepared as part of the Corps' "Evaluation of Environmental Investments Research Program", serves as a guide for conducting cost effectiveness and incremental cost analyses for the evaluation of alternative environmental restoration and mitigation plans. It presents a procedural framework for conducting the cost analyses and discusses how they fit into, and contribute to, the Corps' planning process.

Water Resources Council. 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. Washington, DC.
This manual establishes the appropriate concepts, procedures, and techniques for analytical studies conducted by the Corps to evaluate the National Economic Development benefits of civil works plans.

Factor Income/Productivity Method

Batie. S.S. and J.R. Wilson. 1978. "Economic Values Attributable to Virginia's Coastal Wetlands as Inputs in Oyster Production". *Southern Journal of Agricultural Economics*. 1:111-118.
This article reports the results of a study which used the factor income/productivity method to estimate the value of wetlands for oyster fisheries. The study estimated a production function for oyster harvest in Virginia that related harvest to human fishing effort, wetland area, oyster grounds, and other explanatory variables. The parameter estimate for the wetlands variable was multiplied by the dockside price of oysters to calculate the marginal contribution of wetlands to the fishery.

Freeman, A. M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future. Washington, DC.
This text provides a thorough review of the current state of the art of the theory and practical application of resource valuation techniques. The factor income/productivity method is discussed in Chapters 4 and 9.

Grigalunas, T.A. and R. Congar (Eds.). 1995. *Environmental Economics for Integrated Coastal Area Management: Valuation Methods and Policy Instruments*. Regional Seas Reports and Studies No. 164. United Nations Environment Program.
This document provides an overview of environmental and natural resource valuation techniques and policy instrument, with a focus on applications in coastal area management.

Lynne, G., P. Conroy, and F. Prochaska. 1981. "Economic Valuation of Marsh Areas for Marine Production Processes." *Journal of Environmental Economics and Management*, 8: 175-186.
This articles reports a study which estimated a bio-economic production function relating blue crab harvest in Florida that explains catch as a function of the quantity of wetland marsh and human fishing effort. The estimated parameter for the wetland variable was used in conjunction with data on the exvessel price of crabs to derive a marginal value for an acre of marsh in the production of blue crabs.

Travel Cost Models

Bergstrom, J. C. and H. K. Cordell. 1990. "An Analysis of the Demand for and Value of Outdoor Recreation in the United States." *Journal of Leisure Research* 23(1): 67-86.
Demand equations for 37 outdoor recreational activities were estimated using a multi-community, multi-site travel cost model. This model represents an alternative approach for estimating standard values for outdoor recreation over multiple populations and sites.

Bockstael, N.E., W.M. Hanemann, and C.L. Kling. 1987. "Estimating the Value of Water Quality Improvements in a Recreation Demand Framework." *Water Resources Research* 23: 951-960.
This paper describes three types of recreational demand models developed to estimate the value of water quality improvements by observing recreationists visiting sites with varying water quality and access costs. The models described are: systems of demands, discrete choice (travel cost) models, and the hedonic travel cost approach. The latter two are demonstrated using a common data set on water quality and swimming behavior in the Boston area. The authors compare and contrast the hedonic and discrete choice models, concluding that, while slightly more cumbersome, the discrete choice model provides more descriptive results.

Brown, G.M., and R. Mendelsohn. 1984. "The Hedonic Travel Cost Method." *Review of Economics and Statistics* 66(3): 427-433.
The hedonic travel cost method, which estimates how much users are willing to pay for the individual characteristics of outdoor recreation sites, is applied to value steelhead fish density in Washington State streams. By observing how much further fishermen travel to reach better quality sites, the researchers were able to estimate a price for quality.

Fletcher, J.J., W.L. Adamowitz, and T.Graham-Tomasi. 1990. "The Travel Cost Model of Recreation Demand: Theoretical and Empirical Issues." *Leisure Sciences* 11: 119-147.
Selected theoretical and empirical issues related to the travel cost model of recreation demand are reviewed. Behavioral underpinnings of the model are examined, common problems and their potential solutions are identified and discussed.

Forster, Bruce A. 1989. "Valuing Outdoor Recreational Activity: A Methodological Survey." *Journal of Leisure Research* 21(3): 181-201.
The economic literature focusing on the monetary valuation of outdoor recreation activity is examined. The travel cost method, the contingent valuation method, and the hedonic methods are discussed, with a focus on design and application issues, and how they have been addressed to date.

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future. Washington, DC.
This text provides a thorough review and assessment of the current state of the art of resource valuation, both theory and methods. Travel cost models are discussed in Chapters 4 and 13.

Hansen, W.J. and D.D. Badger. 1991. *National Economic Development Procedures Manual--Recreation: Volume IV, Evaluating Changes in the Quality of the Recreation Experience*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 91-R-7.
This manual, which is part of a series of manuals designed to provide recreational evaluation procedures to implement the U.S. Water Resource Council's *Principles and Guidelines,* focuses on evaluation of qualitative differences in the recreational experience. It describes procedures and methods for valuing changes in recreational use values that result from management decisions impacting on recreational facilities nd services.

Hufschmidt, M.M., D.E. James, A.D. Meister, B.T. Bower, and J.A. Dixon. 1982. *Environment, Natural Systems, and Development: An Economic Valuation Guide*. The Johns Hopkins University Press. Baltimore, MD.
This text provides an introduction to economic methods for valuing environmental and natural resource systems. The travel cost method is described in Chapter 6.

Mendelsohn, R. 1994. "Modeling the Demand for Outdoor Recreation." *Water Resources Research* 23(5): 961-967.
The author provides a critical review of several recreational demand modeling techniques. Various methodologies are introduced, including the multiple-site travel cost models, hedonic property value, hedonic travel cost, generalized travel cost, and discrete choice models. Limitations and inadequacies associated with these methodologies are noted, and additional research needs identified.

Smith, V.K. and W.H. Desvousges. 1985. "The Generalized Travel Cost Model and Water Quality Benefits: A Reconsideration." *Southern Economic Journal* 52(2): 371-381.
The authors provide a revised version of a previous model designed to estimate the value of water quality benefits using travel cost data. They proceed to demonstrate the resulting differences in the model results, revealing the sensitivity of benefit estimates to modeling and estimation judgments made by the researcher. Research implications include the need for better information on households' recreation decisions and a more complete description of recreation site characteristics that are hypothesized to affect those decisions.

Smith, V.K., W.H. Desvousges, and A. Fisher. 1986. "A Comparison of Direct and Indirect Methods for Estimating Environmental Benefits." *American Journal of Agricultural Economics* 68: 280-290.
This paper compares the two classes of methods available for estimating consumer values for improvements in environmental resources, direct and indirect methods. Direct methods include the various constructed market formats, while indirect methods include the several travel cost and hedonic models advanced in the literature.

Vincent, M.K., D.A. Moser, and W.J. Hansen. 1986. *National Economic Development Procedures Manual--Recreation: Volume I, Recreation Use and Benefit Estimation Techniques*. U.S. Army Corps of Engineers, Institute for Water Resources. IWR Report 86-R-4.
This report provides an expanded description of the recreation evaluation procedures recommended in the Water Resources Council's *Principles and Guidelines*. It summarizes the conceptual basis of procedures for recreation valuation, describes the mechanics of the travel cost method and other acceptable valuation techniques, and offers criteria for determining the applicability of various methods to particular planning studies.

Hedonic Property Value Method

d'Arge, R.C. and J.F. Shogren. 1989. "Non-Market Asset Prices: A Comparison of Three Valuation Approaches". In *Valuation Methods and Policy Making in Environmental Economics*. F. Folmer and E. Von Ierlan (eds).
This chapter reports on the results of a study which used the hedonic property value method to evaluate the differences in demand around two glacial lakes in Iowa.

Feather, T.D., E.M. Pettit, and P. Ventikos. 1992. *Valuation of Lake Resources Through Hedonic Pricing*. U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources. IWR Report 92-R-8. September 1992. Fort Belvoir, VA.
This report describes the application of the hedonic property value method for the evaluation of lake resources. Hedonic models are developed to test three hypotheses: 1) land value of lakefront property is greater than non-lakefront property, 2) the effect of lake characteristics is realized in land values, and 3) water resource related impact on land values diminishes with distance from water sources. Results confirmed all three hypotheses and illustrated the usefulness of the technique for evaluating environmental amenities such as lake resources.

Freeman, A.M. 1993. *The Measurement of Environmental and Resource Values: Theory and Methods*. Resources for the Future. Washington, DC.
Chapter 11 of this text provides a detailed description of the history , underlying theory, and applications of hedonic property value pricing.

Palmquist, R.B. 1991. "Hedonic Methods". In *Measuring the Demand for Environmental Quality*. J.B. Braden and C.D. Kolstad (eds). North Holland. Amsterdam.
This chapter provides a comprehensive discussion of the theoretical and empirical issues involving the application of hedonic methods, including hedonic wage and property value models.

Ridker, R.G. 1967. *Economic Costs of Air Pollution: Studies in Measurement*. Preager. New York.
This text included the first attempt to use residential property value data as the basis for estimating the benefit sof changes in environmental quality. It describes the first use of the hedonic property value method to measure the influence of air pollution on residential property values.

Thunberg. E. and L. Shabman. 1990. *Determinants of Residential Landowners' Willingness-to-Pay for Flood Hazard Reduction*. U.S. Army Corps of Engineers, Institute for Water resources.

This study derived an estimate of the value of flood control for relieving property owners' anxiety and reducing community disruptions. These findings were developed while controlling for flood insurance impacts.

Contingent Valuation Method

Boyle, K.J. and R.C. Bishop. 1987. "Valuing Wildlife in Benefit-Cost Analyses: A Case Study involving Endangered Species." *Water Resources Research* 23: 943-950.
This research represents an early attempt to empirically estimate wildlife nonuse values. A contingent valuation survey was developed to estimate individuals' values for the protection of endangered species. Results suggest that significant values associated with endangered species of wildlife exist above and beyond those that arise from viewing the species in the wild. The researchers support inclusion of nonuse values in the resource valuation process.

Cameron, T.A. 1988. "A New Paradigm for Valuing Non-Market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression." *Journal of Environmental Economics and Management* 5(3): 355-379.
This article provides an alternative welfare estimation approach for the analysis of discrete choice data using censored logistic regression. This approach bypasses the utility function entirely, deriving welfare estimates more directly through a reparameterization of the expenditure function.

Carson, R.T. 1991. "Constructed Markets." In *Measuring the Demand for Environmental Quality*, North Holland. Amsterdam.
The author provides a current overview of the theory and methodology of constructed market techniques, including contingent valuation, contingent choice, and contingent activity models. Constructed market design, sampling design, administration, and estimation issues are discussed.

Carson, R.T. and R.C. Mitchell. 1993. "The Issue of Scoping in Contingent Valuation Studies." *American Journal of Environmental Economics* 75(Dec): 1263-1267.
This paper is a response to critics of the contingent valuation method (CV), who argue that CV is incapable of demonstrating scope (which refers to the sensitivity of value estimates to different levels of resource change), and is therefore too unreliable to obtain useful information in natural resource damage assessments. The authors question these conclusions based on some evidence from the larger CV literature (primarily based on user surveys) and by a reanalysis of some of the studies developed by the critics.

Carson, R.T., J. Wright, A. Alberini, N. Carson, and N. Flores. 1994. *A Bibliography of Contingent Valuation Studies and Papers*. La Jolla, CA: Natural Resource Damage Assessment, Inc.
A recent bibliography listing most contingent valuation studies and related research produced over the past two decades.

Cummings, R.G., D.S. Brookshire, and W.D. Schulze. 1986. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method*. Rowman and Allanheld. Totowa, NJ.
This text summarizes the results of a conference convened to assess the contingent valuation method (CV). Most notable are the reference operating conditions, various recommendations which were suggested to help validate CV estimates of environmental values.

Freeman, A. M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future. Washington, DC.
This text provides a thorough review of the current state of the art of resource valuation, identifying the strengths and weaknesses of various estimation techniques. The contingent valuation method is discussed in Chapter 6..

Harrison, G.W. 1993. "Valuing Public Goods with the Contingent Valuation Method: A Critique of Kahneman and Knetsch." *Journal of Environmental Economics and Management* 23: 248-257.

The author examines the admonitions of Kahneman and Knetsch (1992) against the casual use of the contingent valuation method. The author concludes that the evidence provided to support the claim that the method suffers from an embedding effect, or that willingness to pay should be interpreted as the "purchase of moral satisfaction," is insufficient to test the implied hypotheses, that it is incorrectly reported, and that it is in large part fully consistent with accepted economic theory.

Hausman, J.A. (ed). 1993. *Contingent Valuation: A Critical Assessment*. Contributions to Economic Analysis. North Holland. Amsterdam.
This text provides a skeptical review of the contingent valuation method (CV), providing experimental evidence that CV surveys suffer many deficiencies that have not yet been adequately overcome.

Kahneman, D. and J.L. Knetch. 1992. "Valuing Public Goods: The Purchase of Moral Satisfaction." *Journal of Environmental Economics and Management* 22: 55-70.
The validity of the contingent valuation method is questioned in this skeptical review. The results of an experiment that demonstrates the presence of embedding effects are presented and discussed. The authors also conclude that contingent valuation responses reflect the willingness to pay for the moral satisfaction of contributing to public goods, not the economic value of these goods. (This article evoked two noteworthy responses: Smith (1992), and Harrison (1993)).

Loomis, J.B., W.M. Hanemann, B. Kanninen, and T. Wegge. 1991. "Willingness to Pay to Protect Wetlands and Reduce Wildlife Contamination from Agricultural Drainage." In *The Economics and Management of Water and Drainage in Agriculture*. A. Dinar and D. Zilberman (eds). Kluwer Academic Press. Boston, MA.
A contingent valuation survey was developed to estimate the value for California residents of alternative programs to expand wetlands and reduce wildlife contamination in the San Joaquin Valley. The authors conclude that Californians value clean water supplies for refuges at over $3 billion a year, and suggest that there should be some reallocation from agricultural uses to wetland restoration.

Mitchell, R.C. and R.T. Carson. 1989. *Using Surveys to Value Public Goods: The Contingent Valuation Method*. Washington, DC: Resources for the Future.
This text may be considered the CV "how to" manual, providing a systematic review of the contingent valuation method and its application. The theoretical basis of the methodology is identified, measurement biases, sampling and aggregation issues are addressed, and suggestions made for future research.

Opaluch, J.J., S.K. Swallow, T. Weaver, C.W. Wessells, and D. Wilchens. 1993. *Journal of Environmental Economics and Management*. 24: 41-59.
This article describes an approach to facility siting that ranks potential sites in terms of their social impacts. A contingent choice survey based on paired comparisons is used to construct a utility index to rank sites consistent with predicting results of a hypothetical referendum based on the attributes of sites.

Randall, A. 1991. "Total and Nonuse Values". In *Measuring the Demand for Environmental Quality*. J.B Braden and C.D. Kolstad (Eds). North Holland. Amsterdam.
This book chapter discusses the evaluation of nonuse demand using the contingent valuation method. It provides a thorough treatment of the issues associated with breaking down total resource value into categories such as use and nonuse value.

Schkade, D.A. 1994. "Issues in the Valuation of Environmental Resources: A Perspective from he Psychology of Decision Making". *Environmental Evaluation and Decision Making*. Issue No 96 (Summer).
This article argues that use of the contingent valuation method for estimating the benefits of the Corps' ecosystem restoration efforts is of questionable value because a true parameter value that represents the public's monetary value for restoring environmental resources probably does not exist in any practical sense.

Shultz, S.D. and B.E. Lindsay. 1988. "Measuring the Public's Perception of Water Resources Using the Contingent Valuation Method." *Water-Use Data for Water Resources Management*, Proceedings of a Symposium, American Water Resources Association, Bethesda, MD. pp. 159-169.
The basic theory and necessary fundamentals of the contingent valuation method are reviewed. The potential advantages and limitations of applying the methods to water resource issues are illustrated by highlighting an experiment to determine household willingness to pay for groundwater protection in New Hampshire.

Smith, V.K. 1992. "Arbitrary Values, Good Causes, and Premature Verdicts." *Journal of Environmental Economics and Management* 22: 71-89.
This paper offers an alternative interpretation of the conclusions that Kahneman and Knetsch (1992) reach based on two contingent valuation method surveys. The evaluation argues that while framing is important to CV estimates, the design, implementation, and empirical findings reported from these surveys do not support their judgments. The author concludes that based on existing evidence, CV is the "best available procedure" when applied properly to situations in which conventional protocols are used to ensure that people understand what is being asked of them.

Whitehead, J.C. 1993. "Total Economic Values for Coastal and Marine Wildlife: Specification, Validity, and Valuation Issues." *Marine Resource Economics* 8: 119-132.
Using data from a contingent valuation survey of nongame wildlife programs in coastal North Carolina, this paper provides evidence that total economic values for wildlife under uncertainty are theoretically valid. The research suggests that in models that do not include measures of uncertainty, specification error is present, which can lead to errors in benefit estimation.

Whitehead, J.C. and G.C. Blomquist. 1991. "Measuring Contingent Values for Wetlands: Effects of Information About Related Goods." *Water Resources Research* 27: 2523-31.
This paper estimates willingness to pay for preservation of the Clear Creek wetland in western Kentucky when faced with surface coal mining. The authors tested for the effects of explicit information about related environmental goods on contingent values. Their findings suggest that lack of explicit information about related environmental goods can contribute to a misstatement of willingness to pay.

Benefits Transfer

Boyle, K.J. and J.C. Bergstrom. 1992. "Benefit Transfer Studies: Myths, Pragmatism, and Idealism." *Water Resources Research* 28(3): 657-663.
In this paper, the authors propose a systematic, conceptual foundation for conducting benefit transfer studies, and suggest a research agenda to identify conditions under which valid benefit transfer estimates can be derived. They conclude that the research agenda must be accompanied by improved conduct and reporting of original valuation studies before benefit transfer can become a widely used tool in public policy analyses.

Desvousges, W.H., M.C. Naughton, and G.R. Parsons. 1992. "Benefit Transfer: Conceptual Problems in Estimating Water Quality Benefits Using Existing Studies." *Water Resources Research* 28(3): 675-683.
The problems encountered in using existing studies to measure the benefits of water quality improvements are investigated in this paper. The authors propose criteria for selecting transfer studies and present a case study of a valuation model transfer. They conclude that existing studies were not designed for transfer, thus placing limitations on the current effectiveness of transfer, and suggest future research to address these limitations.

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Luken, R.A., F. R. Johnson, and V. Kibler. 1992. "Benefits and Costs of Pulp and Paper Effluent Controls Under the Clean Water Act." *Water Resources Research* 28(3): 665-674.
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McConnell, K.E. 1992. "Model Building and Judgment: Implications for Benefit Transfers with Travel Cost Models." *Water Resources Research* 28(3): 695-700.
In this paper, it is argued that standard hypothesis testing in model estimation is less important than the researcher's judgment about how the model ought to work. The author suggests that there are several major research issues which may influence final benefit estimates that are determined by the researcher. The author concludes that original benefit estimates which were tailored for a specific application cannot be treated as is they came from a strictly random process.

Parsons, G.R. and M.J. Kealy. 1994. "Benefits Transfer in a Random Utility Model of Recreation." *Water Resources Research* 30(8): 2477-2484.
Data on Wisconsin lake recreation is divided into two non-overlapping samples, Milwaukee residents and non-Milwaukee residents. Several hypothetical transfers are developed from a non-resident random utility model to residents. Transfer results are then compared with the random utility results from the resident model ("true" values). In this experiment, transfer values are reported to deviate by less than ten percent from the "true" values.

Smith, V.K. 1992. "On Separating Defensible Benefit Transfers from 'Smoke and Mirrors'." *Water Resources Research* 28(3): 685-694.
This paper illustrates the need for guidelines to decide when benefit transfer methods can be used to value changes in environmental resources. It proposes an agenda for future benefit transfer research: devising strategies for extending available benefit transfer theory, learning from existing research, and formulating transferable versus "portable" modeling strategies.

Walsh, R.G., D.M. Johnson, and J.R. McKean. 1992. "Benefit Transfer of Outdoor Recreation Demand Studies, 1968-1988." *Water Resources Research* 28(3): 707-713.
This paper illustrates how the results of previous studies could be adjusted to develop some tentative estimates of nonmarket values for future policy analysis. The authors analyze estimates of economic values per recreation day for 19 different recreational activities based on a meta-analysis of 120 recreational demand studies conducted from 1968 to 1988. The authors note that the evaluation of some potentially important variables should help improve statistical analysis and the allocation of resources to new studies, while identifying the need to examine additional variables that might conceivably be more important that those considered in the past.

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This manual establishes the appropriate concepts, procedures, and techniques for analytical studies conducted by the Corps to evaluate the National Economic Development benefits of civil works plans.